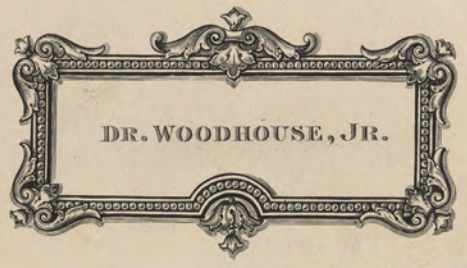

Notes

from

Lectures on Chemistry

delivered in the University

of

Pennsylvania

by

James Woodhouse M.D.

in two volumes

Vol. 1

# Notes from Lectures on Chemistry delivered in the University of Pennsylvania by James Woodhouse M.D.

In two volumes

Vol. I

# Contents of Volume I.

# Contents of Volume I.

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# Contents of Volume II.

Doctor Woodhouse in a very eloquent introductory Lecture expatiated on the utility of Chemistry as applied to Medicine Agriculture & the Arts.

## Lecture 2.nd

Gentlemen.

Before we proceed to take notice of the immediate objects of Chemistry we will say a few words of its Origin and Progress

The History of Chemistry may be divided into three parts Mystologic Obscure & Certain.

1.st The Mystologic

Those who suppose the Honour & Dignity of a Science depends on its Antiquity date the Origin of Chemistry at a very early period They urge that Tubal-Cain (who is probably the Vulcan of fabulous History) was a very good Chemist but he has certainly no more right to that appellation than a Blacksmith for that most certainly was his Occupation

They tell us that Moses was well acquainted with Chemistry the solution of the Golden Calf is the argument by which they establish this opinion if the Calf was of pure Gold this must have required consummate skill but it is strenuously asserted by some that

the Calf was wood & only covered by thin plates of Gold in this case the process was considerably easier the most probable opinion is that Moses dissolved the Gold by Hepar Sulphuris this solution is characterized by a very nausious taste the remembrance of which probably kept the Israelites from committing the like Idolatry in future. The Ancients had undoubtedly some Ideas of Fermentation Noah is spoken of as the first who used the Juice of the Grape this we know would not have intoxicated him unless previously fermented. The Ancients had also knowledge of the Art of Dying (which depends entirely on Chemistry) the purple colour was well known to the Egyptians who valued it highly & used it in Divine Worship. It is agreed on all hands that the Egyptian Priests were the first who paid any attention to Chemistry.

## 2nd Obscure

This Authors mention as commencing at a very early period and continuing near thirteen hundred Years during which time the rage for converting the baser metals into Gold was universal and overspread all Europe. The Men engaged in this pursuit were denominated Alchemists. They beleived

fully in the possibility of this they thought that God entrusted the secret to a few highly favoured persons whom they called Adepts they beleived that should those Adepts divulge the secret they would be severely punished. Much has been said for and against the possibility of converting certain metals into Gold this has never yet been satisfactorily demonstrated tho' it is impossible to disprove it.

The following Anecdote in favour of Alchemy we find in the Writings of Helvetius. An Englishman by the name of J. Bond waited on Helvetius informing him that he had discovered the Philosophers Stone shewing him at the same time a substance which he called by that name Helvetius earnestly requested a peice of the Stone which the Englishman in spite of all his entreaties denied him but promised to return in the course of three Weeks he performed this punctually Helvetius had while examining the Stone rubbed off a few fragments from it with which he in vain endeavoured to convert some Lead into Gold he therefore despaired of success but seeing the punctuality of Bond he renewed his entreaties for a peice of the Stone Bond gave

him a small peice Helvetius thinking it not sufficient the other generously gave him half leaving him with directions how to use it & promising to return in half an hour to inspect the operation Helvetius waited impatiently for his return but at last resolved to try the efficacy of his present before his Wife and Family. Having melted six drachms of lead in a covered Crucible he exposed it to a violent heat for the space of three quarters of an hour at the expiration of which time he threw in a small quantity of the Stone and to his very agreable surprise the whole mass was converted into Gold at first of a greenish colour which upon cooling subsided and the Metal appeared with all its brilliancy & splendour. The Jewellers pronounced the Gold very pure. As we have no confirmation of this extraordinary Anecdote it must rest entirely upon the authority of Helvetius.

Helvetius was certainly a very accurate Chymist & was the first who called the different Gases by their names. It is impossible (says the admired Author of the Botanic Garden) to deny the possibility of converting the Metals into Gold. The spontaneous formation of Lapis Calaminaris and many facts

equally curious which present themselves daily to our observation forbid our saying that by some happy combination of principles Gold may not be produced

After Helvetius, Avicenna arose who studied Chemisty with unremitting attention and augmented the store of knowledge in this Science. Chemistry was now introduced into England and there cultivated by some Characters. Roger Bacon now appears in the Philosophical World he made much progress in Astronomy Mathematics &c. &c.

He first invented Spectacles and all Glasses for the enlargement and diminution of the appearances of Bodies. His knowledge of Nature and her Laws was so great as to cause him to be suspected for a Magician and persecuted as such the Vulgar being fully persuaded that he dealed with the Devil. —

He discovered the composition called Gunpowder in his writings he ingeniously confesses that Nitre and Sulphur are constituent parts but conceals the Charcoal in an Anagram (see Nitre)

Paracelsus in Germany succeeded him he called himself Aureolus Phillippus Theophastus Bombastus Paracelsus de Hohenheim was born at

Einsilden about two Miles from Zurich in 1493 at three Years old he was made an Eunich by accident he died in 1541 aged 48 although he had promised himself an Immortality by the use of his Elixer his illness lasted but a few hours he was most undoubtedly a very singular Character at the Age of 20 he began his Travels through Germany and the Neighbouring Country visiting all the Mines of Metals which he heard of in his way by which means he became a very good Metallurgist & Mineralogist. He returned home & published nine volumes on this and other subjects which were so poorly received that he resolved to keep the tenth in his Occiput he was persecuted in a very severe manner for his publications & thought to be a Magician. When Paracelsus was seated in the Professional chair he kindled a fire in his Chimney threw some Nitre & Sulphur into it and laid the Writings of Galen & Avicenna upon it. He was the first who had dared to oppose Galen who before his time had reigned the Tyrant in the Schools of Medicine. He used to say that if the Almighty refused to impart knowledge to Man he was justifiable in asking assistance of

the Devil. He treated all his contemporaries with the most supreme contempt which assisted no doubt in gaining him enemies. He was certainly a very curious Man and committed many irregularities he was driven from his Native Country and forced to seek a livelihood elsewhere his persecutions without a doubt exceeded his Crimes

3 Certain

Van Helmont now enters the Chemical World he was the first who called the Air by the name of Gases Carbonic Acid was his gas Sylvester After him a long list of Chemist in England France & Germany assisted greatly in the promotion of the Science the well known Lavoisier that victim of Robespierian Tyranny assisted greatly in this work his princely fortune aided him in the cultivation of the Science & few Chymists can boast of more accuracy in Analysis and experiment In England Lord Verulam espoused the cause of Chemistry Boyle also assisted more in the cultivation of Chemistry than almost all who had gone before him

he possessed a very large estate which enabled him to keep a number of Workmen constantly employed in experimenting, in short his whole time and Fortune were devoted to Philosophy & Chemistry

When the Cartesian Philosophy was so much in vogue Mr. Boyle refused to read the Writings of Des Cartes lest the plausibility of his reasoning might lead him to believe things not demonstrable by experiment – About this time the Royal Society of London was instituted, at first a few Gentlemen met at their own houses & expence, but it soon encreased to its present respectability ——

Stahl now added his Mite to the common stock, Chemistry was not much cultivated in England as the Philosophy of Sir Isaac Newton engaged the learned of that Nation Black however immortalized his Name by his Chemical researches and the well known French Chemists have at last brought that valuable Science to its present advanced stage of Perfection ——

# Lecture 3rd of Heat

Before we begin to treat of the subject of our present Lecture we must observe that we do not pretend to account for it — Lord Bacon thought that it was owing to motion — Boyle was of the same opinion to prove this hypothesis they observed that Iron by being briskly hammered became heated — that two pieces of Wood by being rubbed often inflame (in this manner Savages procure fire —

The objections to this Theory are —

1 Heat is not in proportion to motion

2 There may be motion without heat and heat without motion —

A Second hypothesis is that it is a fluid different from all known fluids of very great subtility which has some analogy with Electricity — tho' it differs very materially

from that fluid - Heat tends constantly to equilibrium - if a piece of Wool at 40°. a piece of Wax at 30°. and a piece of stone at 50°. were shut up together in the same temperature they would all acquire the same temperature in a short time - Heat resembles electricity in some respects but differs ~~xxxxxxxx~~ very materially from it in some others - Heat and electricity both pass through bodies heat much sooner than electricity - the electric spark is always of one colour whereas the rays of fire are of different colours, as red blue green white &c. A sphere of Metal loses heat sooner than it acquires it - this is not the case with electricity - Heat increases fluidity - electricity has not this effect —

Electricity may be smelled its odour resembles that of Phosphorus, heat is perfectly inodorous - . Boerhaave made some experiments to ascertain whether heat was ponderous, he

× This may be explained by the Air becoming rarefied over the heated body consequently the pressure was less on it than on the weight —

Dr. Woodhouse explains the increase of weight from an absorption of oxygene in that state.

weighed an Iron bar before it was heated and found it acquired 1/16 more weight when hot but I think must have been owing to some inaccuracy in weighing —

Heat is subject to certain laws, they are as follows —

1 The communication of heat is common to all bodies and peculiar to none constantly tending to equilibrium — this shews the expansive power of heat which always endeavourists recede from the centre

2 The communication of heat takes up some time and different times for different bodies

3 Two bodies of the same quantity & quality of matter receive and lose heat in proportion to their surfaces, thus a cube of Gold will receive & lose heat much more slowly than a gold leaf containing the same quantity of the metal

4 Two bodies of the same form & matter but different in quantity heat & cool in proportion to their diameters —

5 Heat passes out of bodies quickest in proportion where the layers are finest —

6 Heat is communicated to bodies in proportion to their contiguity of parts. thus it will pass out of one cube into another quicker than out of one sphere into another, because in the spheres there is but one point of contact

7 Surfaces & bulks being given they lose and receive heat in proportion to their quality what this quality is we know not — Muschenbrock says it is owing to the density of bodies but this is not the case — it is an inherent quality of substances with which we are totally unacquainted

Those substances which conduct heat are generally nonconductors of electricity. they are

1 Moist air — 2 Fluids of all sorts — 3 Metals some of which are much better conductors of heat than others, to prove this. if you fasten a peice of Bees Wax upon a peice of brass wire another peice upon Iron wire & a third on leaden wire — and if the three peices of wire

* Excepting Copper which is a better conductor than any other Metal —

be heated gradually at their opposite extremities the wax on the Brass wire will be fused first and that on the Iron next and that on the leaden wire last, this proves that Brass is the best conductor of heat ×

4 Glass tho' a very good conductor of heat is a nonconductor of electricity —

The nonconductors of heat are 1st Wood. 2d Wool hence this is a very excellent substance to clothe sheep & other animals as it prevents heat from escaping from their bodies, Wood by being a nonconductor of heat is of great use in making handles for different instruments which are heated frequently in the fire — 3 Charcoal tho' a powerful conductor of electricity is a nonconductor of heat — 4 Feathers. hence of use in preserving Birds from the cold. & hence the propriety of a german custom of covering themselves with a small bed of feathers in winter as it prevents the escape of heat from their bodies — 5 Hay — 6 Straw — hence Ice

Houses are surrounded with straw to prevent the fusion of the Ice blankets are also useful for the same purpose — 7 Fur & Hair of all kinds, hence the hardy Laplander covered with the hides of numerous animals slain in the chase, is enabled to look with indifference on the shivering European and thinks himself supremely happy in veiwing the immense castles of Ice which float about his coast with perfect unconcern —

8 Snow & Ice — being no conductors of heat is the method which bountiful Nature takes to preserve the fertility of the soil of cold countries, by coating them with snow they preserve their heat & it is generally the case that the ~~more~~ colder our Winters are the more snow we have —

Air is cooled in passing over land hence North America is colder than England tho' in parallel latitudes — and hence Sailors

can tell when they approach land by the great difference in the temperature of the air

Air is warmed by passing over Water and hence Islands are warmer than Continents

The Sun has no action on transparent bodies, a burning lens is not heated when a piece of wood below it is burning, if you throw the focus of a lens upon the bottom of a bucket filled with water the wood will burn while the water will not be heated. from these experiments we infer that the sun acts only on opaque bodies & of course the Earth being heated warms the air, so that we do not believe the air to be warmed by the sun's rays — hence the air is warmest near the earth and colder in proportion to the distance from it. this also accounts for hail storms, snow &c when the air near the earth is quite warm

We come next to consider the causes which

produce diversity of Climate —

The 1st we shall take notice of and at the same time the most powerful is the perpendicularity of the Sun's rays, this is too well known to need any explanation —

2d Contiguity of high Mountains — these render adjacent countries warmer in Winter by defending them from the cold winds and cooler in Summer by preventing the powerful action of the rays of the Sun —

3 We before observed that Air is warmed by passing over Water, and hence Islands are more temperate than Continents this may in part be owing to the constant fogs & mists which are constantly to be seen on the coasts of Islands, these intercept the rays of the Sun and so prevent very great heat — 4th State of culture of adjacent countries has a most powerful effect on the temperature of a Country — Italy affords

a most striking proof of this assertion —

It was some years ago a very cold country Horace in his 2d Ode tells us that he was well acquainted with the horrors of Winter, but so great is the difference in that climate now that the Italian is a perfect stranger to Ice & Snow — To what shall we refer this great alteration? not to the cultivation of Italy for in the time of Augustus, that country was much more highly cultivated than it now is, we must look further than the narrow limits of Italy and turn our attention to the neighbouring countries, the industrious kingdoms of Germany Poland &c. we shall behold a most surprising alteration in the state of culture and to this cause we must attribute the change as the air is warmed in passing over these countries —

5th Quality of soil has a material influence

on climates - stony is much colder than sandy soils - Gypsum is much colder than calcareous earth —

6 Large masses of Ice floating near the sea coasts of a country causes the climate to be much colder - A late Author observes that could the wealth of Nations instead of being employed in Wars for the destruction of the Human species - be used in navigating the immense masses of Ice situate near the Pole and which are constantly & rapidly encreasing into the South Sea it would be productive of the most beneficial advantages to mankind in general - the advantage would be two fold, in the first place the Ice in melting would cool the tropical countries and secondly Greenland, Iceland, Lapland Norway &c. &c. would be warmed in great measure by the removal of the great cause of their

intense cold — The Winters in Philadelphia are not near so cold now as they were 50 Years ago owing probably to the state of culture in surrounding parts — And my ingenious Colleague and former Preceptor Doctor Rush has indulged his imagination in foreseeing a pleasing change in our climate, this will probably take place but I fear we shall not enjoy the advantages of tropical climates without participating in their diseases. the Yellow Fever of 1793 the repetition of it in '94. '97. & '98 appear to be the precursors of the fatal diseases which infest the West Indies and other tropical situations ——

Before I finish this subject I will take notice of a circumstance which has engaged some Philosophers attention and been the subject of curious speculations — but to which no satisfactory explanation has yet

been affixed – It is a current of warm air (which some say is of a spherical form) which rolls as it were along the surface of the earth, it most frequently happens in the evening sometimes about Noon but I have never known them to take place in the morning – the place I have observed it is at Gray's ferry near some very large rocks of granite, another place is near to Mount Holly in New Jersey State – some have attributed them to Volcanos, but no volcano's exist in New Jersey or this State, so that it is probable that is not the cause –

## Lecture 4.th

On our last Lecture we took notice of Heat – our next subject is its effects, these are four viz. Expansion, Fluidity, Evaporation & Ignition –

1 of Expansion. most bodies

I

expand differently when heated - expansion is proportional to heat applied, expansion by heat may be easily proven, take a cylinder of Iron or any other Metal fit it to a hole in another piece of Iron the Iron when ignited cannot be thrust into the hole, or if a bar of Iron 8 or 10 inches long be heated to redness, it cannot be put into a vessel of that length, expansion of fluids is seen in Thermometer

We prove the expansibility of air by taking a bladder half filled with air & heating it by the fire, the air expands & burst the bladder thus then solid liquid & aeriform bodies are expanded by heat and in proportion to heat applied - this effect of heat is thought to be owing to the fluid of heat insinuating itself between the particles of Matter -

Boerhaave was the first who took notice of this effect of heat, by heating a glass tube six feet long he found it very sensibly increased in length his observation was made

public and others investigated the subject more fully — There are exceptions to the expansive power of heat, Animal & Vegetable substances are rather made less than greater by the application of heat — when a very gentle heat however is applied they are expanded but when the heat is increased they contract sensibly — Water is another exception to this general rule it takes up a much greater space when solid than when in its usual liquid form — Mr. Huygans burst cannon by putting water in them, stopping them up tight and freezing the Water Bomb shells have also been burst by the congelation of this fluid — A quantity of Water was put into a tube of metal & 70 lb weight placed upon the top of it, the Water was congealed and the weights were thrown off with great violence from the top of the tube — Philosophers have been much puzzled

to account for this — Homberg & Black thought it was owing to a combination of air with the Water at the moment of its freezing their opinion was founded on the bubbles which they found in Ice, but some later experimenter has pierced those bubbles and fill'd them with water and the same expansion took place, again water which has been boiled and deprived of all air expands in the same manner —

Mr De Maizan thought it owing to a confused chrystalization the chrystals always uniting at angles of 60° or 120° — this may be seen very evidently in a flake of snow which puts on a stellifoim appearance —

From the expansive power of heat Thermometers are constructed — for thermometers those substances are chosen which are most sensible to the different degrees of heat, of course fluids are chosen, four of these substances have been used in the construction of

Thermometers - Air, Alcohol, Oils, and Mercury - The first attempts for the admeasurement of heat were made by Sanctorius who used air as his expansible body - He sealed a glass tube hermetically at one end this tube he exposed ~~an expanded~~ to the temperature he wished to ascertain & dipped the open end into Alcohol coloured by cochineal in proportion as the tube cooled the coloured fluid rose into it - It must be seen at the first glance that this way was very inaccurate for it depends entirely on the height of the Barometer - i.e. the density of the atmosphere

Oil of annised and other fixed oils were next used in thermometrical observations -

Boyle and the Florentine Academicians used Alcohol in their experiments - this fluid is very sensible to heat & answers very well for low degrees but as it boils at 175° of Fahrenheits scale it does not answer for the

greater degrees of Heat — Mercury is best adapted for Thermometers and is the only fluid now in use it requires a very strong heat to make it boil & freezes at 39° below 0° of Fahrenheit when however very low degrees of heat are to be measured spirit of wine or petroleum may be used with advantage —

By thermometers our Ideas of heat are greatly enlarged, we learn that no body in nature is so cold but what contains some heat — the usual methods of making those instruments is to provide a tube of a proper diameter, the bore of this tube must be an exact cylinder to ~~ascertain~~ this some Mercury suppose an inch must be introduced at one end of it, if this Mercury measures one inch in every part of the tube the cylinder is exact, a bottle ~~of the~~ gum elastic filled with air is now to be fastened to one end of the tube and the other end must be exposed to the flame of a blow pipe untill

it melts, it must now be sealed hermetically and the bladder of gum elastic squeezed so as to form a globular bulb at the fused end of the tube (an oval bulb would be preferable to a spherical one) - while the bulb is still very hot and the air in the tube consequently much rarefied the open end of tube should be dipped into some pure crude quicksilver as the tube cools the weight of the air will press up a quantity of Mercury into the tube, when a sufficient quantity is in the tube the thermometer should be taken up and the quicksilver boiled in it so as to force out all air that may exist in the tube or quicksilver. thus a Vacuum is formed in the tube, the open end must now be sealed hermetically and the bulb dipped into snow or water at the freezing point a mark is to be made where the mercury is with a file, it is next to be dipped into boiling water & a mark made there also -

To construct a scale according to Fahrenheit, the intermediate space between freezing & boiling should be divided into 180 equal parts each of which is to be called a degree 32° is marked opposite the freezing point & 212° opposite the boiling - & the instrument is complete —— To ascertain proper points for fixing the Zero or 0° was long a matter of difficulty, some thought the temperature of a cave a certain distance under ground would be the most proper, but this would be far from accurate - nor is the present mode so accurate as might be wished for the boiling point often varies from 205° to 213° owing to the different pressure of the Atmosphere - the scale of thermometers should be graduated while the Barometer stands at 29½ inches which is the mean degree of pressure

Another scale which is used in

Thermometers (by the French only) is one invented by Reaumer his freezing point is at 0°. or Zero and his boiling point at 80°. —

There remains one objection to these thermometers which is that the Mercury does not continue at the highest degree of heat which it has been exposed to and of course unless the moment be seized when this is the case the temperature cannot be exactly ascertained. Mr. Six has remedied this inconvenience by putting a peice of Iron on the surface of the Mercury, the Iron rises with the mercury & remains at the highest point of temperature, it may be drawn down by means of a magnet ——

## Lecture 5th —

The most accurate thermometers which we use are those made by Mr. Wilson of Glasgow, whose method of making them was described in the last lecture — the

Glass of thermometers (especially at the bulb) should be thin when wanted for nice experiments

Heat a positive cause. Cold a negative being nothing more than the absence of heat. the English language tends to preserve the Idea of cold being absolute which is certainly not the case. We are apt to imagine that fluidity is the natural state of water but this is a vulgar error ——

Water may be made to feel cold to one Person, warm to a second & neither warm nor cold to a third, thus if you dip your hand into snow and after a few minutes put it into water at 62°. ~~it feels cold~~, the water will feel warm, if you take your hand out of water at 90° and put it into the same water at 62° it feels cold, & if your hand be at the same temperature with the water it feels neither hot nor cold, so that we may conclude that heat & cold are altogether relative — for we know not when one ends & the other

begins — Musschenbroek & other Philosophers have agued in favour of cold being a positive cause, he endeavours in 13 arguments to establish his proposition but he failed in them all his opinion is that it is owing to frigorific particles but the opinion is certainly absurd —

We spoke of the admeasurement of heat by thermometers at our last lecture and described the methods of making those instruments as practised by Mr. Wilson of Glasgow, but for the admeasurement of higher degrees of heat Mr. Wedgewood has contrived a Pyrometer on the principle that pure clay contracts in proportion to heat applied to it — It consists of two parts the guage & thermometer pieces — the guage is made by fastening two rules of brass upon a plate of the same metal — their distance from each other at one end is half an inch and at the other three tenths of an inch, the length is divided into 240

equal parts and each of those parts is one tenth of an inch in length the rules must be perfectly straight & two feet long for the more convenient carriage the guage is divided into two equal parts To form the thermometer peices the pure clay must be reduced to an impalpable powder made into a paste of the proper consistence with water & thrust through a cylinder to give it the proper shape & size, they must now be baked with a low heat to give them the proper consistence if any of the thermometer peices are too small and slides into the guage the degree to which it goes must be marked upon it & subtracted from the calculation when it is to be used — When it is to be used one (or more) of the thermometer peices is to be expond to the required temperature (suppose a glass house furnace) it is suffered to remain there a few minutes & then is taken out and applied to the guage to determine how great may be the contraction —

This instrument must be in a cavity as the brass will absorb heat & expand while the clay will also expand with heat & shrink

At first view we would suppose this to be a very accurate instrument, but I think it is not so much so as we would suppose - I exposed four of the thermometer pieces to the same heat, in the same crucible, in the same furnace, & under every similar circumstance which could in the least influence the experiment and they contracted the first piece to the 12th degree, the second to the 13th the third to the 13th & the fourth to the 14th - In other experiments I have been equally deceived -

The only use which this instrument has hitherto been applied to - and for which it seems very well calculated is to ascertain the different degrees of heat requisite for fusing the different kinds of glass & enamel of porcelain and other potteries. Thus it answers the purpose of the Inventor - It has taught Chemists also the degrees of heat at which the different Metals fuse as for instance

Brass melts at 21° of Wedgewood –
Copper . . . 27° –
Silver . . . 28° –
Gold . . . 32° –
Iron . . . 90 –

It teaches us also the different degrees of heat excited by different fuel as Charcoal – Wood – Pit-coal &c. &c. of course what fuel to choose for different purposes, upon the whole it is a useful Instrument & the Inventor deserves the thanks of Chemists for so ingenious a discovery ——

## Lecture 6th –

### II Of Fluidity

Fluidity is the consequence of heat as much as expansion, the Metals and many other solid bodies become fluid by heat – and many bodies as Water Mercury &c. – which are fluid at the common temperature of the atmosphere may by decreasing that temperature be rendered solid – It has been urged that certain Earths

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and some other substances are always & necessarily solid, but I doubt not that if we were able to apply a very intense heat to those substances they might be melted —

Muschenbroeck who supposes cold to be a positive cause affirms that Water is necessarily fluid & that its solidity is owing to a combination of certain frigorific particles — Hew

1.st Because water may be kept from freezing when the temperature of the air is below its freezing point, if it be kept perfectly still, but if it be shook it freezes. He says because the agitation causes it to unite with frigorific particles; but we may explain it by supposing the Water to evaporate in some manner by the agitation and so heat is disengaged from it more speedily —

2.nd That frost often continues at the temperature of 41.° Fahrenheit. We admit the fact & explain it by supposing that Ice &

Snow require a long time for the reception of a sufficiency of heat to fuse them, difference of Soil may also have a considerable influence on it for snow remains much longer on an argillaceous than a Sandy soil ——

3.rd Because Water often thaws at 30° Fahrenheit which is two degrees below the freezing point — This may have been owing to the soil being sandy, or the Thermometer being placed against a cold wall, or if a severe frost had preceded it would have had some effect on it — as Water gives out heat in becoming solid —

4.th That frost often exists on Vegitables when no Ice is found upon Water — This we readily explain by the seventh law of heat, that is we suppose that the vegitables are nonconductors of heat and consequently must be colder than the atmosphere ——

5.th Because frosts often occur in April May & June, this he says cannot have been

owing to the Water parting with its heat — But we may readily explain it by evaporation, for very hot days are often succeeded by very cold nights —

6th Because frost is more common in the North than in the southern parts of Europe — This may be owing to the southern parts being surrounded with water which tends to keep a Country warm —

7th Because stagnant water freezes less readily than that which is exposed to the Air This we explain by supposing the cold air to succeed that which is warmer & comes in contact with the water & so deprives it of its heat —

8th Because a mixture of salt & snow will freeze water by the fire side — which we readily explain by supposing that it absorbs the heat of the Water in its funion & not because it contains frigorific particles —

9th Because Nitric acid added to Ice produces

Cold to water it evolves heat - This is also explicable without figorific particles

10th Because hoar frost is seen after Sunrise and not before - This may be owing to the heat of the sun producing evaporation & so cold

11th Snow water he says is hard untill boiled, he supposes boiling evolves the figorific particles & so softens the water - (hardness, means that water does not dissolve soap readily) - The fact is that snow Water is as soft as rain water if the temperatures be equal ——

12th - He says the Inhabitants of the Alps are afflicted with Guttur Tumidum (Quis guttur turmidum miratur in alpibus) this he says is owing to their drinking snow water - But the Inhabitants of the Andes drink snow water yet they are not afflicted with this disease -

13th That all bodies but water contract

by cold and that it enlarges, this must be owing says he to the accession of frigorific particles - But Ice is not heavier than water, but this he says is owing to the subtility of the particles, but Metals expand in becoming solid. they cannot absorb the frigorific particles when red hot - Water expands by its confused chrystalization

Baron Van Swieten abetts Musshenbrocks opinion of frigorific particles - he infers it from the circumstance that Russians cure frozen Ears by applying snow to them, he says the frigorific particles which exist in the ear have it to unite with the snow, but this inference is wrong - the way in which it acts is by being somewhat warmer than the ear, it acts as a stimulus to the ear & adds heat to it - he also says the frigorific particles may be seen by immersing a frozen Apple under water - but

this is not the case, small spiculae it is true are seen when a frozen apple is immersed under water, but this is nothing more than frozen water in form of spicula or chrystals, if the apple be put under warm water the Ice will be dissolved and no spicula be seen —

Alcohol & Ether cannot now be frozen, but yet I think it probable that we are totally unacquainted with the greatest degree of cold — and Chemistry now makes such rapid strides towards perfection that I should not be surprized to hear in a few years that the gases have been frozen, so fully convinced am I that heat is necessary to fluidity — Mercury which was also thought necessary fluid has been frozen — A Russian Chemist by the name of Lowitz has fixed it, with a mixture of equal parts of Muriate of Lime & snow —

Mr. Walker an english apothecary says he can freeze it in the summer by means of this mixture — Heat exists in two forms either

Caustic alkali when mixed with water generates heat, with ice, cold.

Sensible or Latent, to prove this Dr. Black took two Iron pots equal to each other in every particular & heated them both to redness into one he threw a pound of Ice and into the other a pound of water at 50° he found the water was heated to 212° and the Ice to 132° now he concludes that 72° must have entered into a latent state or else the Ice water would have acquired a mean temperature between 32° & 50° which is 18° less heat than the water – Upon this principle we explain the cold produced by the Solution of different salts – viz. by absorbing heat in passing to the state of a fluid – The mixture which produces the greatest degree of cold (or rather absorbs the most heat) is 11 parts of Sal ammoniac 10 of Nitrate of Potash 16 of Sulphate of soda and 32 of Water by Weight ———

## III Evaporation

By this we mean the dissipation

of Bodies in form of a compressible elastic fluid called steam or vapour capable of condensation by cold and greater rarefaction by heat. boiling of water affords a familiar example of evaporation. In this also we see that Vapour is formed at the part most heated (and not as the French chemists suppose at the surface) We prove the elasticity of vapour in the same manner as of air, one drop of water confined in a tube of glass closed at both ends being put into a candle or other hot place explodes with a loud noise bursting the glass into a thousand peices - 212° of Fahrenheit is the point at which water evaporates but when it is compressed it may be heated to redness as in Papins digester - In the Eolipile large quantities of water are converted into vapour (called eolipile from Eolus the God of the winds) Doctor Mitchell thought he had made an useful discovery when he observed that the steam from this instrument

enlivened coals exposed to it, Doctor Priestly made the same observation in consequence of which a Gentleman in this State erected a large one for the purpose of bellows to some Iron works but found to his expence that it put out all his fires — The fact is the coals are enlivened by a current of air which passes along with the vapour, but the moment the coal is completely immersed in it — it is extinguished and Doctor Mitchells supposition expires with the coal —

## Lecture 7th —

Evaporation has given rise to a very useful discovery in the art of blowing glass, the glass blowers by blowing a little spittle through the tubes which they use are prevented the trouble of blowing a very great quantity of air from their Lungs when they make large spheres or balloons of Glass — the spittle is converted into vapour which expands by

the heat and is so rarefied as to take up a very large space – Another valuable discovery which it has given rise to is that of Steam Engines some of which raise weights which would take 600 Horses (and then very stout) to do —

We observe that pressure influences this effect of heat hence on high mountains where the pressure of the Atmosphere is less, fluids boil at a much less heat than in Vallies – Ether boils in vacuo at a very moderate degree of heat the hand can give it a sufficiency of heat for this purpose, The instrument used in this experiment is a glass tube with a large bulb or hollow sphere at each end which contains a quantity of Ether coloured red with cochineal, the hand being placed on one bulb all the Ether boils out into the other* (the greatest care must be taken to exhaust almost all the air) —

* Dr Woodhouse doubts this, he says it is owing to the small quantity of the air in the vessel being rarefied and so passing through the fluid —

Evaporation is assisted by a current of air which carries off the vapour as it forms and so makes room for more to take its place — hence the use of Fans, Ventilators &c - in the summer, which only give a passage to warm air yet they cool by carrying off the Vapour as it forms on our Faces &c. from perspiration —

Evaporation generates cold by the vapour uniting with the heat and flying off from the liquid, hence Turks cool Wine & Water Melons by wrapping them up in a wet cloth and exposing them to heat in the sun in order to evaporate the water from the cloth - this abstracts heat from the Melon or Wine & it is cooled — Hence also Reapers are cooler when they perspire most Hence Glass blowers Blacksmiths &c &c - are enabled to live in a temperature much greater than that of their bodies (which is about 96°) — by freely perspiring - Electricity facilitates evaporation and promotes perspiration —

It was long thought that the human body

could not bear a degree of heat greater than that of 96 or thereabouts 100. degrees at the outside but late experiments have proven that it bears with facility a degree of heat very far superior – besides the thermometer in this City often stands at 100° and upwards in the summer 140° in the Sun very often – and in many parts of Africa it stands at a degree far superior to this & the Inhabitants are as healthy as those of more Northern Climates – The experiments alluded are those related in the Philosophical Transactions – Doctor Dobson remained in a room gradually heated to the 224° of Fahrenheit without much inconvenience – Doctor Blackden remained 12 minutes in a temperature of 220° – Doc. Fordyce repeated the experiments and gradually increased the temperature from 90° to 120° then he stripped off his clothes & went into a room at 110° where he sweat very profusely – during the above experiment the Mouth and Skin of those Gentlemen where only 100°

but 4° above the natural standard - 260° was afterwards borne by them with tolerable ease Water placed in those rooms in shallow vessels boiled instantly - These experiments prove that the body when it perspires is less heated than the surrounding Air ——

Ice and Snow evaporate when the Atmosphere is below the freezing point - this may be observed by exposing a peice of Ice on all night (in very cold weather) it is found sensibly diminished in the morning - The snow evaporates at Hudsons bay (says Doc.r James) without fusion

The experiments of Doc.r Winter related in the Philadelphia Philosophical Transactions put the matter beyond a doubt - he mixed some Salt & Snow together, he placed a tumbler containing a lump of solid Ice into this mixture & inverted another tumbler over it - both tumblers were now covered with the freezing mixture and in a few minutes

× This is more properly sublimation, it takes place when the atmosphere is below the freezing point, consequently the Ice is warmer than the surrounding Atmosphere and sublimes —

# A cheap method of cooling wines is by mixing Glaubers Salt with diluted Sulphuric Acid, this produces a cold below the freezing point —

The vessels used by the Persians will not cool liquor in this Country, our atmosphere contains too much moisture.

the upper tumbler was lined with a coat of Ice or frost ×

The persians cool their wines by putting them into vessels made of porous clay, the Wine filters out and is evaporated by the Suns heat this evaporation cools the Wine very completely This custom is so very prevalent that some Asiatic Cities make those cups the sole object of their commerce – a corroborating proof of our assertion that evaporation generates Cold ++

## IV Ignition –

All bodies which are heated till they emit light are said to be ignited – this is the most uniform effect of heat – the point of ignition is nearly the same in all bodies about the 600° of Fahrenheit – Mercury boils before it ignites – Bodies may bear a greater degree of heat than ignition – Vis Isaac Newton says Iron is ignited at 600° but may be heated to upwards 1000° of Fahrenheit – all bodies may be ignited – Vapour confined in a

VI

Digester becomes red hot - The point of evaporation is much more irregular for some bodies become evaporized before they assume a liquid form as Camphor &c. - - We proceed next to take notice of the next subject in order -

## Mixture -

By mixture we mean the union of dissimilar bodies - The effects of this are very different, some bodies unite homogeneously as spirit & water, others for a short time as oil and water, some unite with violence and impetuosity as Acids & Alkalies, some produce cold as the solution of deliquescent Salts -

Mixture is divided into Chemical Mixture: Solution and Diffusion - of each of which we shall treat in order -

I Chemical Mixture - In all chemical mixtures there are a menstruum or solvent (called menstruum because the old Chemists employed a month in all their solutions) and the Solvend or the body to be dissolved -

A change of properties is always the consequence of Chemical mixture. a Tertium quid is the result which possesses the properties of neither the constituent parts. e.g. Volatile alkali & Vitriolic acid are both violently caustic, but when united form a mild neutral salt which differs essentially from both — again muriatic acid & Mercury neither of which are poisonous, when combined in the form of Corrosive sublimate destroy Life by their poisonous quality. The following circumstances are observed in all chemical Mixtures —

1st They possess none of the properties of their constituent parts —

2nd They invariably generate heat —

3rd Only two bodies can be mixed at the same time 4th Bodies which were volatile become more fixed by mixture. There are exceptions to the above observations, but when taken together they seldom fail of characterizing chemical mixtures —

II Solution. By solution we mean so intimate a division of one body by another that they appear homogenous, in this as in chemical Mixture we consider the Menstruum & Solvend. It differs from the former in the circumstance that there is no change of properties in the latter & in solution there is generally a generation of cold or to speak more properly an absorption of heat —

Solution is divided into seven different kinds

1st Maceration. This is when the Menstruum is heated to the point of ebullition —

2d Infusion. This is when the Menstruum is poured boiling on the solvend & suffered to cool —

3d Decoction. Consists in the continued application of the boiling heat —

4th Digestion. Is when the solution is performed in close vessels and the Menstruum is heated above the boiling point —

5th Circulation – Is when the vapour which arises in boiling is condensed and returned again to act on the ~~[illegible]~~ solvend –

6th Deliquescence – Is when a body spontaneously dissolves in the open air by attracting aqueous particles, of this we see an example in Oil of tartar per deliquium –

7th Amalgamation – Expresses the union of Mercury with a Metal ——

The following circumstances are observable in solutions –

a. Bodies dissolve quicker in proportion to their surfaces – hence the use of powdering the solvend, and of agitation as both tend to bring more particles into contact –

b. It is assisted by heat, hot water dissolves much more of a salt than cold (Muriate of soda excepted)

c. Contact of air assist solution this is proven by placing a saturated solution of sea salt or nitre under the exhausted receiver of an air pump when all the salt will precipitate

III Diffusion - Called mechanical solution to distinguish it from true solution, this is known by its turbid appearance and requires agitation to keep the solvend suspended - An instance of diffusion is seen in a Mixture of clay & Water, the clay falls to the bottom unless agitated

## Lecture 8th -

## Of Decomposition -

By this we mean the separation of the constituent parts of bodies it is performed in three ways - viz. by Precipitation Chrystalization & Evaporation —

1st Precipitation - By this is meant the separation of bodies dissolved, e.g If we add a third body to a solution of a solvend in a Menstruum and if the body added separate the two it is said to be precipitated — The body added is called the precipitant, the one separated the precipitate ——

We distinguish three different kinds

× 4th. Of the Menstruum, if to a solution of Gold in Aqua Regia we add Ether the Ether unites to the Gold & suspends it above the Aqua Regia. this is a good test for trying the purity of Gold, if Copper is mixed with the Gold it is precipitated

of precipitation — a. Of the dissolved body alone if for example we add pot-ash to a solution of Marble in the Sulphuric acid, the acid unites with the potash & the marble is precipitated

b. Of the dissolved body with the precipitant e.g. If to a solution of marble in Nitric acid we add sulphuric acid this last unites with the marble and falls with it to the bottom —

c. Of the Menstruum with the precipitant e.g. If to a solution of camphor in alcohol we add Water, the alcohol unites with the water and both are precipitated ×

2.rd Chrystalization — This is when bodies assume a regular geometrical figure and depends on the diminution of heat in the Menstruum, and on the contact of the air — this is proven by the following experiment take a quantity of Glaubers Salts and dissolve it in the smallest possible quantity of Sgle water heated beyond 212°. by placing it in a boiling

Solution of Muriate of Lime, put this solution while boiling in a matrass, tie a strip of moist bladder over the Matrass so as to exclude all air (for as the aqueous vapour fills the matrass no atmospheric air exists in it) this solution may remain for Years and no chrystalization takes place, if the bladder be cut off the whole is instantly converted into a solid chrystalized mass —

3.d Evaporation — This is the most easy and useful method of ~~evaporation~~ decomposition it consists in the dissipation of the more Volatile parts from those which are more fixed It is best performed in wide shallow vessels, this Lavoisier doubts as he says that evaporation is proportional to the heat the solution possesses, but the wider the vessel is the more speedy is evaporation, for it permits the air to carry off the evaporated matter as it forms, it should be often stirred while evaporating

Sir Isaac Newton was the first who introduced the attractions into notice - The chemical ~~attractions~~ affinities differ from the attractions of Cohesion, Magnetism, Gravitation &c for they do not act upon large bodies, as the latter do - nor unless in contact, thus Mercury & Sulphur never unite unless triturated - The Chemical affinities do not act upon solid bodies for a favorite chemical maxim is - "Corpora non agunt nisi soluta" -

The minuteness of dissolved bodies is almost inconceivable, if 1/40 of a grain of sea salt be dissolved in half a gallon of water it may be detected by the addition of one drop of a solution of nitrate of Silver ——

An instance of simple elective attraction is seen in precipitation, the precipitant having a stronger affinity to the Menstruum than the Menstruum has for the solvend unites with it & the solvend is precipitated e.g. If to a solution of Muriate of ammoniac

in Water we add Potash, an elective attraction ensues; the Muriatic acid of the sal ammoniac unites to the potash forming Muriate of Potash or digestive salts of Silvius while the ammoniac is disengaged in form of alkaline gas.

Double Elective Attraction - is when to a solution of a compound substance we add another compound substance and a mutual change of principles ensues - thus if to a solution of sulphate of Iron we add a solution of acetate of Lead a double elective attraction takes place - Acetate of Iron & sulphate of Lead being formed —

We now pass to the different modes of producing and applying heat —

1st From Animal bodies; as this is the same at all times it has seldom been employed but for graduating Thermometers

2d The collision of solid bodies this is so transitory as to be seldom used except for kindling fires and exploding Gunpowder —

3d Electricity this also is transitory, used only in exploding Hydrogen gas & decomposing some of the airs, more of which hereafter —

4th Fermentation — This heat is about 120° Fahrenheit it is of use where a low uniform heat is required as in the formation of Verdigris Cerum & the like — Dung is often used for this purpose — A Gentleman in New-England won a wager by producing Water Melons in Winter without earth, water, or dung, he succeeded by using oak bark after the Tanners had used it — Eggs may be hatched in the same way —

5th The heat of the Sun formerly called ~~exsiccat~~ Insolation much used in extraction of Balsams, Resins, Gums &c — and other vegetable Juices & also in inspissating them — This is also used in the fusion of refractory earths & metals, for by means of a Lens or concave Mirror a most intense heat may be produced —

× Spirit of Wine often burns the Wicks, Silver Wire twisted & Asbestos answer much better than cotton for wicks

6th Fuel – of which there are very many sorts we shall defer them untill our next lecture –

## Lecture 9th –

The different Fuels may be divided into two kinds Fluids & Solids ——

1st Of Fluids, there are spirits of wine and different fixed Oils, oils being cheapest are most used, they emit a large quantity of Soot which when collected is sold by the name of Lampblack – Mr Argand has very ingeniously remedied this inconvenience by inventing a Lamp of great use in small Chemical experiments – The wick of this Lamp is circular and a constant current of fresh air is afforded through the center, which gives heat enough to burn all the smoke – This lamp may be made to give out a very intense heat when required called from its inventor Argands Lamp

Spirit of Wine emits no smoke but its costliness prevents its coming into general use x ——

2d Solids - These are Peat or Turf - Charcoal, Fossil coal - Wood - and Dung of Animals -

Peat or Turf is very spongy and light a sufficient quantity for the production of a strong heat cannot be put into a furnace It answers very well for a low heat, It is used by Peasants for Cooking &c. &c. ——

Charcoal this is prepared by dissipating the Resinous Gummy &c, parts of wood, by charring it that is heating it to ignition and then extinguishing it by covering it with Earth this produces an intense heat, with little smoke, and is much used in Chemical operations - It kindles very easily and burns without flame

Fossil Coal charred, this contains more inflamable matter than Charcoal much Bitumen and burns with the emission of much smoke leaves ashes behind which vitrify and clog the fire place - It is used where large quantities

of a cheap fuel capable of producing an intense heat are wanted as at Glass houses, Iron Works & the like - It is called coke in England -

Dung of Animals, this is very little used in Europe - Asia and especially Egypt lack wood, coal, & every other fuel but this, it is therefore used by the lower class of Egyptians & Asiatics - it is collected in heaps, and dried in small sheds, hence we understand the meaning of the Scripture phrase of "Embracing the dung heap" it was applied to those who were so destitute as to seek shelter from the Inclemency of the Sky in those huts —

Our next business is to exhibit and explain the Chemical Apparatus - a knowledge of this part of our Course is indispensably necessary to every one who pretends to study Chemistry, and tho' by no means the most interesting part of our Course is by no means to be neglected —

Chemical Vessels to be perfect should possess the following properties —

1st They should be transparent in order for us to see the different changes which take place in our experiments —

2d They should resist the action of all our tests &c —

3d They should be capable of bearing the most sudden changes from extremes of heat to cold without cracking —

4th They should be free from pores and capable of confining the gases & liquids — &

5th They should bear the most violent constant and intense heat without melting

We are as yet unacquainted with any substance which possesses all the above enumerated properties, and must be directed in our choice by the nature of the operation which we wish to perform — e.g. when we want to apply a very intense heat, as in fusion of Glass or the refractory Metals we

use Crucibles made of Earth, which are almost infusible, where we want to apply a more gentle heat without any sudden transition to cold as in Distillation &c - Glass is the best substance we are acquainted with

Glass possesses the two first properties but wants all the rest - It is however very generally made use of for Chemical vessels The thinner glass vessels are made the more they resist transitions from heat to cold - & vice versa - Glass for chemical purposes should be well annealed, i.e. baked with a low red heat for a considerable time, this prevents their cracking - Glass which has not undergone this process is very brittle & breaks by slight pressure in the hand into a thousand peices, as in Prince Ruperts drops which are made by fusing glass and dropping it when fused into cold water - The Author of the Botanic

Garden (Doc. Darwin) has accounted for this in a manner no less curious than true –

Metals, these are used where low heat is wanted as in distillation on the large scale They possess the 3 & 4 properties but are destitute of all the others – The acids act on them – They are readily fusible & they are opaque – Silver & Gold are not however liable to all these objections, for the Acids in general have no action on them – (the Nitric & Nitro Muriatic excepted) They might therefore be used but their price & scarcity prevent them from coming in general use – Lead answers for the distilling Sulphuric acid – Copper for the distillation of Alcohol & some of them may be made use of for some operations and others for others

Earths – These possess the 5th property in a very eminent degree but they want

all the rest - for they are opaque - they crack if heated or cooled suddenly - they are liable to corrosion by the acids & vitrify if the very strongest heat is applied to them -

When a proper mixture is made of them they form very excellent crucibles especially if Plumbago be added - Clay and Sand and Plumbago are often used for this purpose - Metallurgists use them in the fusion of Metals, their only objection to this purpose is that they often flux when very strongly heated -

Having pointed out the proper materials for making those vessels we will proceed to say a few words upon the vessels themselves and the processes in which they are used -

1 Distillation is made use of to separate volatile principles from fixed when it is intended to preserve the former

It consists in evaporating & condensing the

Vapours so as to collect them again in the liquid form - distillation is said to be made in three different ways viz Distillatio per Ascensum, per Descensum and per Latum - the first is most commonly made use of when it is to be carried on in the large way as in the distillation of Brandy it is performed in a Still which you have all seen - the Vapour which rises is condensed in a refrigeratory or worm pipe which is surrounded with Ice or cold Water - The second mode is entirely laid aside it was done, by applying the heat to the top of the vessel -

The third mode is most commonly used in small experiments it is performed by the retort & Receiver, when the retort is perforated it is called a tubulated retort & the perforation is called the tubulum the lower globular part is called the belly of the retort & the long beak is called the

Neck, the longer this is the more speedy will be the condensation of the vapour

The recipient or receiver is surrounded with Ice or cold Water to assist the condensation this receiver should be as capacious as possible - When a violent heat is used the belly of the Retort is coated with a lute as chemists call it. A variety of lutes have been invented for this purpose A mixture of Cowdung & Clay is often used Plumbago is often mixed with them - the only lute I use is a paste compond of flour and water

2d. Apparatus for the application of heat are called furnaces (for a description of the endless varieties of these see the common books on Chemistry also Nicholsons Chemical dictionary article apparatus) Black's furnace is called a portable one, but it is almost immovable by its weight, it is a very complicated & useless machine -- In furnaces

we consider the fire place, the chamber or Laboratory and the Ash hole - the vessels are exposed in the laboratory - the fire is placed in the fire place - the ash hole should be very capacious - the larger the Chimney the greater will the heat be - Lewis's furnace is the most simple & useful one I am acquainted with

3 Wolfe's apparatus is used in the distillation of very volatile acids & the originated Muriatic is procured by means of it -

We shall not pretend here to describe all the various apparatus which are used in Chemistry but shall describe them as they occur in our experiments

We will conclude this Lecture with an easy mode of cutting glass, which tho' it may appear trifling now, you will often find of use - If it is a bottle or large cylinder which you wish to cut

mark round it with a file & put a red hot Iron in the mark, this will crack the glass and by drawing it round you cut the glass off - if it be a small tube you may cut it with a file - another method is by tying a peice of twine covered with sulphur round the vessel and burning it, while the glass is hot throw some cold water on it and the glass will break off - Glasses may be mended when broken by putting some fat cheese boiled with quick lime to the consistence of a paste on their edges

## Lecture 10th -

We have now arrived at a very interesting part of our course - the consideration of Aeriform fluids or gases - and first of Hydrogene Gas or Inflamable air

It has acquired the name of Inflammable

Air from its property of burning when in contact with pure Air, called Hydrogene Gas from its being a constituent part of Water, from Υδωρ Aqua and Γενναω Nascor or Gignor - Hydrogene Gas possesses the following properties —

1st It is the lightest of all aeriform fluids upon this property is formed the Theory of Balloons - that of Montgolfier is very different it depends on the rarefaction of the common air of the Atmosphere —

2d It is improper for combustion or respiration as a taper is extinguished the moment it is plunged in it & Animals die who respire it - There has been much disputing among Chemists concerning the respirable property of Hydrogene Gas some contending that it is & some that it is not respirable - Pilatre du Rozier inspired some of it, & put a candle to his

Mouth in expiration it formed a curious Jet of flame - he then mixed it with some common air & inspired it but when he attempted to set it on fire the consequence was so dreadful an explosion that he imagined his Teeth were knocked out of their ~~Mouth~~ Sockets - Some say that no ill consequences result from inspiring hydrogene gas but of this I am not convinced - I procured some Hydrogene Gas last Winter from Zink & Marine acid, I took a large inspiration of it, went home without feeling any ill unpleasant, excepting a Catarrh which had worried me for some days before, I called out afterwards & in coming home was seized with a most violent pain in my back & loins, this continued increasing till I got home, when in making Urine I perceived that little else than pure blood flowed out, this alarmed me, I sent for Doctor Otto who took ℥xx blood from me

directly - I was however in spite of this precaution laid up for five weeks, with what Doctor Rush called Yellow Fever
This experiment however is not conclusive for I did not wash the gas and in all probability some marine acid gas passed over along with the Hydrogene
Schule says that twenty inspirations may be taken without inconvenience as he has inspired that often himself -
Rabits live different lengths of time in different species of Inflammable air some four minutes others two - Some Writers say that hydrogene is the least deleterious of the gases excepting oxigene which alone is proper for respiration - Beddoes and Watt say hydrogene is deleterious but that Hydro-carbonate is much more so -
This latter species of inflammable air has been used as a Medicine in Pulmonary Complaints - At first it was comfortable

to the Lungs; the Patient requested a repetition of it. the dose was now increased but diluted with more common air 100 ℥ measures of Hydro-carbonate & 600 ℥ of Atmospheric air were given — The Patient was seized with Vertigo, and some other alarming symptoms coming on, the Physician desisted from the further application, when the patient complained of a very curious sensation of relaxation at Sphincter Vesicæ urinaria —

3d. It possess a curious disagreable odour which according to Pinnan may be taken away by receiving the gas over Mercury —

Hydrogenous gas may be procured from most substances, in which it is a constituent part the purest is that obtained from the decomposition of Water, and this way is commonly used to obtain it for Chemical experiments, for this purpose Sulphuric acid diluted with 8 or 10 parts Water are added to Iron filings or Zink (Marine

Acid is also used) the oxigene of the water unites with the Iron or Zink & oxides while its Hydrogene escapes the acid now dissolves the metalic oxide (to prove that oxigene and hydrogene form water explode a mixture compound of 85 parts of oxigene with 15 of hydrogene and 100 of water will be produced) Hydrogene gas is often produced by decomposing water in a different way viz by passing steam of water through a white hot Gun barrel in either case the air is received in the hydropneumatic apparatus — We will take notice of Doctor Priestly's objections to this method of explaining the experiment —

4th It burns when in contact of Atmospheric air, as may be proved by presenting a lighted taper to the mouth of a vessel containing it & also by Pilatre de Rozier's experiment — If however it be mixed with Oxigene or Atmospheric air (which contains oxigene) an explosion takes place and

Water is produced, Pistol balls and shot may be thrown with violence by exploding ~~by~~ ~~explosing~~ a mixture of the two airs (if atmospheric air is used two thirds should be taken) the explosion with pure air is much greater — By using ⅔ of pure air ⅓ of Hydrogene gas a ball weighing 5 ½ was thrown from a small pistol with great violence against a fence six yards distance from it it is fifty times greater than if atmospheric air is used —

The Electric spark explodes the two gases — it must be conducted into the air through a glass tube by means of a metallic wire — The intrepid & unfortunate Pilatre du Rozier lost his life by this property of Inflammable air, he was sailing in a balloon filled with hydrogene gas, a Thunder storm arose, a flash of Lightning struck the Balloon, it fell and Pilatre was dashed to pieces on the Ground

# Lecture 11th

At our last lecture we considered the properties of hydrogenous gas, it is the lightest we said of all the airs but forgot to mention that 72 inches of it are equivalent in bulk to 720 in. of Atmospheric air, consequently is 10 times lighter than the latter — Fire damp is a species of hydrogene gas which is formed spontaneously in mines (no doubt by the decomposition of water) It aims to some cavity in the roof or top of the mine by its lightness, as it is very impure & is mixed with carbonic acid it explodes on the approach of an ignited body - (for it never explodes but when in contact with oxigene gas and carbonic acid contains this) The miners get rid of it by throwing a lighted candle into it and falling on their faces at the moment of the explosion to avoid the shock, a much better method is to

conduct the Gas by means of a tube to the ash hole of the furnace in which the ore is fused for it would there supply the furnace with fuel —

We observed at our last lecture that sulphuric & marine acids are commonly used to procure this air but strong Acetic & Gallic acids have the same effect —

Inflammable air often holds Charcoal in solution it is then called Carbonated hydrogenous gas or Hydro-carbonate It may be procured by extinguishing an ignited coal under water — In this experiment the water is decomposed — its oxygen unites to the coal and forms carbonic acid — (most of which is absorbed by the water) and its hydrogene escapes holding some of the charcoal in solution — This is more deleterious than pure Hydrogene gas —

Inflammable air often contains Sulphur in solution it is called Hepatic air, or Sulphurated Hydrogene Gas —

It burns with a blue flame and has an unpleasant sulphurous smell. It is produced by pouring an acid (diluted) upon a mixture of Iron filings & Sulphur we will consider it more particularly when we come to treat of Sulphur — It has lately been discovered to constitute the base of Marine Acid —

Another species of Inflammable air is called Carbonated oily hydrogene gas. it is procured by adding 75 parts of sulphuric acid to 25 of Alcohol and distilling them, or by causing Ether or Alcohol to pass over ignited Silex or Glass.

We pass on & consider Oxigene Gas or pure air called also fire air, empyreal air dephlogisticated air &c. &c. called Oxigene Gas because it exists in every acid from Ὀξυς Acidum and Γενναω Nascor, Vital air because it alone is capable of supporting Life — Fire & Empyreal Air because it alone is capable of supporting flame, dephlogisticated air because the Phlogistians say that it is air deprived of Phlogiston

It was discovered by Priestly & Scheele nearly at the same time, tho' both ignorant of each others experiments Scheele emphatically calls it the Elixir of Life, some since its discovery have asserted that the Placenta acts as lungs to the Foetus — (See extracts from Chemical Works of the first Century by Mayo) —

All metallic calces, oxides, (which are compound of oxigene & a metal) when heated yield their pure air and are converted into Metals again In this manner vast quantities of pure air are obtained from Red precipitate which is a calx of Mercury - ℥i of it yields 32 ℥ measures of pure air — Red lead also which is an oxide yields large quantities by the addition of Sulphuric acid & heat — Nitre also yields it in abundance if heated, but the purest we are acquainted with is that afforded by the oxigenated muriate of Potash — 100 grains of this salt yields 75 ℥ of

× This doctrine Dr. Woodhouse proves to be fallacious, the Oxigene is obtained from the Carbonic Acid which is mixed with the Water, this Acid is decomposed its Carbon unites to the Vegetable while its Oxigene is set at Liberty - if distilled Water is used no Oxigene will be obtained - The same effect may be produced by exposing Raw Silk or Wig Glass to the Light under Water -

very pure air – Manganin & Sulphuric acid heated also give out quantities of it, but this is impure holding some acid in solution from which it is separated by agitation in water, One pound of this oxide yield 3384 ℥ measures of it – the green part of vegetables expire pure air* – this appears to be the method which nature takes of maintaining the Salubrity of the air of the Atmosphere – Animals inspire Atmospheric air & expire azotic air vegitables on the other hand inspire azote and expire oxigene, the air may be obtained by exposing the vegetables to the suns light under Water – The light of the Sun is absolutely necessary to this phenomenon for during the Night & when in the shade they expire Mephitic gas, and again the quantity of pure air obtained in this manner is always proportionable to the clearness of the day – Roses & Violets some say

are an exception to this rule but I think those Gentlemen must have been deceived in their experiments by the inaccuracy of the Eudiometer, more of which hereafter — The cheapest and most ready way of procuring it for chemical purposes is by Sulphuric acid & Magnanise, as my manganise is very pure the air is so in proportion & is fit for most chemical experiments —

The properties of this Gas are

1. It is the only air proper for combustion or respiration to prove this if any Animal be exposed for any length of time to an atmosphere not containing this Gas, it dies — If a taper be plunged in any air which does not contain it, it goes out If a candle be blown out & put instantly into oxigen the flame is revived — Lavoisier has taken advantage of this property for the fusion of refractory

Earths & Metals, by feeding his flame with oxigene gas —

2d It is the acidifying principle, it exists in all acids & hence its name of Oxigene With Sulphur it forms the sulphuric acid with Azote the Nitric Acid, with Carbon the Carbonic acid &c. — If sulphur be burned in it sulphuric acid is made — If sulphur be put on the end of a Watch spring or Iron wire & set on fire & instantly plunged into oxigene gas the heat is so great as to burn the Metal — We must not from this infer that simple contact of oxigene is sufficient to convert these radicals into acids or else our Atmosphere would be composed of nitrous acid, on the contrary the most intense heat is required for the conversion of some of them to this state —

## Lecture 12th —

Some French Chemists & Dr. Priestly &c.

say that Azotic air is not the base of Nitric acid but Hydrogene there are most undoubtedly wrong as we shall prove when we treat of that acid

3 It is more ponderous than Atmosphere air - Oxigene is said by some to exist in the air bladder of certain fish This assertion induced me to try whether it is well founded or not - I find the Cat fish and many others which we procure in this City contain nothing but common Atmosphere air —

Oxigene gas produces Animal heat & the red colour of the Blood - It is decomposed in the Lungs, its oxgene (or base) unites with the blood while the heat which kept it in the gaseous state is set at liberty hence Animals are hotter than the surrounding Atmosphere, and hence the heat of Animals is proportionable to the size of their Lungs, of those

Animals - we observe that heat is increased when we use exercise of any kind, this we account for by supposing the muscular action to hasten the circulation consequently the blood passes through the Lungs more frequently & absorbs more oxigene, hence also we account for the heat caused by Anger & other stimulating passions, which also hasten or accelerate the circulation, Anger possesses this power in a very remarkable manner as all of you must have experienced -

Four things are observable in combustion which prove the use of oxigene in that process - 1st Combustion never takes place without vital air be present -

2d In every combustion there is an absorption of vital air —

3 - There is an increase in the

weight of the products of combustion equal to vital air absorbed ——

4th - Light & heat are disengaged in all combustions — The first no one will deny Hydrogene gas, Phosphorus, nothing in nature burns unless oxigene gas be present and it ceases as soon as all the air is absorbed

The second is as true, if Sulphur be burned in pure air, it is absorbed every drop and if other gases exist as in the Atmosphere the oxigene is absorbed and the others remain unchanged — this happens also in the rancidity of oils & oxidation of Metals

The third is more difficult to demonstrate tho no less true — In the oxidation of Metals, the Metal weighs as much more as it absorbed of pure air (as Lavoisier has proven) the same happens in the rancidation of Oils — Inaccuracies often arise in weighing from evaporation

but if the apparatus be covered in which the combustion is performed the same thing will take place — The fourth is the most interesting, in most combustions the Oxigene becomes fixed, therefore abandons it Caloric this endeavours to unite with whatever it meets

Hence it follows —

a. That oxigene contains more heat than other gases, or else all would support flame —

b. That in proportion to the absorption of the oxigene is the heat which is set at liberty —

c. That currents of air expedite combustion by affording fresh supplies of oxigene

d. That the purer the air is the more heat is extricated

e. That fire & heat is greater the more the air is condensed, and hence more Animal heat is generated in Winter than in Summer —

## Lecture 13th —

Oxigene we observed is not chemically combined with Azote in Atmospheric air —

× We divide the Oxygene Gas of the Atmospheric Air which is taken into the Lungs in Respiration into three parts The first portion is discharged from the Lungs in the same state in which it was taken in — The second is decomposed its Oxygene unites to the Carbon which is thrown off from the blood and is discharged from the Lungs in the form of Carbonic Acid, the heat of this portion is necessary to give the Carbonic Acid the gaseous form — The third portion is also decomposed its Oxygene unites to the Phosphorus forming Phosphoric Acid and its heat is set at Liberty, this heat mixes with the blood and is carried by it to all parts of the Body

Nitrous Acid would be the product of this union, It is said that a Chemist in Jamaica has lately succeeded in making Aqua Fortis of Atmospheric air by using an intense heat in some experiments —

We observed also that animal heat & the red colour of the blood are owing to the decomposition of Oxigenous gas or Vital air —

Phosphorus exists in the blood & indeed in every part of the Animal, the oxigenous gas of the atmosphere is decomposed the Oxigene unites with the Phosphorus forming Phosphoric Acid which Phosphoric acid unites with the Iron (which also exists in the blood) and forms a red Phosphate of Iron to which is owing the red Colour, many objections have been made to this mode of accounting for it but it appears the most probable ×

Oxigene can acts through the coats of a blood vessel, if a vein be tyed with a

ligature in two places so that a certain portion of it include a certain quantity of blood and a stream of pure air be passed over the vessel the venous colour subsides instantly and blood acquires a florid red colour as in the Lungs - We affirmed that oxigene supports combustion, in this process three states are distinguishable Ignition - Inflammation & Detonation

Ignition is when a body is heated till it becomes luminous, but still retains its solid form as in the burning Charcoal, Red hot Iron &c -

Inflammation is when a body burns or is heated till it becomes luminous but is reduced to the state of an aeriform fluid producing flame —

Detonation is when a body burns in a very rapid manner accompanied with noise it is caused by a sudden formation of gases or of a Vacuum ——

Professor Chaptal relates a case in which oxigene gas was used as a medicine in Phthisis Pulmonalis with great advantage

A gentleman was in an advanced stage of a consumption, so weak that he could scarcely move, afflicted with diarrhoea and every symptom which portended his approaching dissolution - In this state he was put upon a course of Vital air he respired it with great delight and asked for it with the avidity of an infant at the Breast his strength increased so rapidly that he was able in a short time to walk out and use other exercise, this state of his health lasted for six months, when being in the country and unable to procure Vital air he relapsed & shortly after died

Beddoes on the other hand believes that in Phthisical cases the Atmosphere contains too much pure air & says that the cause of this Gentlemans death was too much oxigene

Priestly respired it & says that it diffu-
a gentle & agreable warmth through his
system he hads that perhaps at some fu-
ture period it may become a fashionable
Luxury — Animals live 5 times as fast
in pure air as in atmospheric air, and this
is probably the reason why it is diluted in
order that they may not live too fast —
The inatability of Animals it is said is
increased in proportion to the pure air
which they respire, It is thought by some
that oxigene is the cause of Salivations —
It is certain that Mercurial Medicine con-
tains a large quantity of it, and that the
Mercury is often revived after they are used
but many facts united to disprove this
hypothesis we shall refute it when we
come to speak of Nitrous acid, we pass
on and consider the next Gas in order —

Azote — called also Mephitic air

Phlogisticated air, Atmospherical Mephitis and by Professor Chaptal Nitrogene gas - Lavoisier has given it the name of Azote from its property of destroying life from the greek letter A non & ZOE vita

Doctor Mitchell called it Septon, because it is obtained from putrifying vegetables & animals (particularly the latter) - from ΣΕΠΩ putrefacio - Chaptals appellation is given to it because it forms the base of Nitrous Acid —— This gas is improper for combustion & respiration, in it Animals die & flame is extinguished, it is lighter than Atmospheric Air, and forms (as we before said) the basis of Nitric Acid

Many methods are used to procure this gas, it exists in all parts of Animal Bodies & may be procured from them by putrefaction or the addition of Nitrous acid

Indeed Animals appear to be Animalized Azote, if I may be allowed the expression the bones tendons ligaments blood muscles and in short every part of the Animal contains Azote, but the muscular fibre and coagulable lymph of the blood contain it in the greatest proportion & from them it is usually procured by adding Nitrous acid and heating it slightly, Carnivorous animals afford more than Herbivorous - It may be procured by placing a mixture composed of Sulphur & Iron filings moistened with water under a given portion of Atmospheric Air - a large vessel such as we use to obtain & confine the gases must be used, it is to be stood in water - The Iron absorbs the oxigene of the Atmospheric air & becomes oxided - As the absorption goes on the water rises in the glass - after two or three

× It may also be procured by exposing ignited Charcoal to Atmospheric Air the Charcoal absorbs the Oxygene forming Carbonic Acid which must be seperated from the Azote by washing

Also by exposing Phosphorus in the same manner. Also by breathing here it will be mixed with Carbonic Acid which must be seperated from it as just mentioned

Also by calcining Iron in Nitrous Air the Oxygene of the Nitrous Air unites to the Iron while the Azote is left in a pure state — It may Also be obtained by the putrefaction of Vegetable substances, the Oxygene unites to the Vegetable, in this manner I procured large quantities while in the Country by exposing a rotten Apple or Pear to Atmospheric Air under a Glass —

days the pure Azote will be left behind It may also be obtained by oxiding a metal or burning a candle in atmospheric air the oxigene will every particle be absorbed and the Azote left — but smoke & other impurities exist in the air when procured thus, Another mode is by exposing a Sulphure of Lime, or Liver of Sulphur to atmospheric air — (in the manner just mentioned) ×

Atmospheric Air — this is composed of 28 Parts of Oxigene & 72 of Azotic gas, they are merely mixed & not chemically combined Carbonic acid exists in the atmosphere but it is an adventitious circumstance and varies in its quantity, the proportions of Oxigene & Azote vary considerably, from 27 of Azote to 30 — We need say little of this fluid as its properties are generally known & understood — Its composition may be proven analitically and Synthetically ——

# Lecture 14th —

## Of Alkalis — Their properties are

1 They change most blue vegetable colours green — Indigo & Litmus are exceptions to this the best test is a tincture of blue Cabbage made by digesting the cabbage in Gin, this tincture does not lose its colour by age and is preferable to the Syrup of violets so much recommended by Authors, as the sugar which exists in it tends constantly to the Acetous fermentation — the skin of Grapes is a very good test, the Convolvulus purpureus &c. &c. —

2d They have an acid caustic urinous taste —

3d Unite with the Earths by fusion especially Quartz, with which they form Glass —

4th — Are perfectly soluble in water & unite with it in any proportion —

5th Form Neutral salts with the Acids and effervesce with most of them —

6th They change certain vegetable Yellows

to a brown colour more especially Turmeric some yellow colours are heightened by them they also turn red vegetables purple as Brazil wood &c ——

7th They render oils miscible with Water —

Alkalis are divided into two classes the fixed & volatile, the fixed are subdivided into the vegetable or Potash & Mineral or soda —

Of the Vegetable fixed Alkali or Potash called vegetable alkalis because it is obtained by burning wood & lixiviating the Ashes called also salt of Wormwood & Salt of tartar because obtained in large quantities from those substances, it is very improperly called Kali because it is obtained from Vegetables which grow near the Sea, Soda might be called Kali with more propriety

A vast variety of vegetables afford Potash, when it is wanted in a state of quick

purity for Medical purposes it is procured from tartar of vegetables by calcination or by detonating Nitre with charcoal and Lixiviating - but these processes are too expensive for works in the large way -

As it is now an Article of considerable trade we shall say a few words of the usual mode of obtaining it - This is by burning wood, making ley of the Ashes & evaporating the Ley till the salt remains dry in the bottom of the Vessel, the evaporating vessel made use of, is an Iron hemisphere Generally speaking the harder & more bitter woods are the more Salt they afford -

White, Black & Spanish Oak are the Wood most commonly burned for this purpose - the following table shews the respective quantities from different woods ——

1000 pounds of Oak yields 111 lbs of Salt

1000 pounds of Wheat stalks yields 198 lbs. of Salt

| | | |
|---|---|---|
| Stalks of Sunflower | 349 | — |
| Vine branches | 162 | — |
| Wormwood | 748 | — |
| Brush | 219 | — |
| Elm | 166 | — |
| Box | 78 | — |
| Aspen | 61 | — |
| 4000 lb. of Fir | 1 | — |

In this Country the scarcity of wood prevents the manufacture of Potash, but in Hungary & other places where wood is plenty whole forests are cut down & applied to this purpose - The management of the fire influences the product, it should neither be too hot nor the contrary. the proper heat can only be ascertained by experience

In Hungary 20 hundred weight are often pounded from 250 bushel of ashes, but here we think ourselves well paid if we get

700 lb. from 400 Bushels — This may be owing to the foreign matter which exists in the ashes of Cities, houses are swept daily and the dust thrown into the fire, another cause may be impure water used in the Liaviation thou tend to introduce foreign Salts & so diminish the value & quantity of the Alkali River or Rain water should be used in the Liaviation —

A curious question presents itself here dia the Alkali preexist in the Wood, or is it a mere creature of the fire?

Mr. Baume made many ~~interesting~~ and curious experiments to determine this point the result of his operations led him to conclude that it preexists in the wood — his experiments were pursued by Margraaf who in some experiments formed Nitre by adding Nitric acid to the leaves of some plants

Nitre may be obtained in this manner from the Sumach or Rhus Vernix & Glabrum the Berries of these poison vines are often covered with the alkali united to the Gallic & Tartaric Acids - Potash as obtained in the foregoing manner contains many impurities

1 Earthy Matter, 2° Foreign Salts -

3 Inflammable matter - 4th Iron & other Metals

The earths are seperated by adding concentrated alkohol to the potash - agitating the two fluids a spontanous seperation soon takes place and the earth will be precipitated in form of a white powder, inflammable matter may be seperated by calcination in the open air, if the Alkali does contain inflammable matter its taste is more pungent and its colour is much blacker - Muriate of Potash often exists in it and may be seperated by evaporation and chrystallization, common salt sometimes exists in it, this is of great

damage to Linnens, it is detected by Alkohol which renders the solution opaque — Potash fuses with a low red heat and in this manner is taken out of the evaporating vessel —

## Lecture 15th —

We said that Nitre is produced by putrefaction, Chaptal by exposing Potash to Bullocks blood in putrefaction obtained Nitre

As the art of Bleaching depends on Potash we will say a few words on that subject at the present time — It is performed most perfectly in Holland — — The first thing done is to steep the linnen for the space of 30 hours in warm Water containing bran —

2d They are washed in a Mill contrived for the purpose, in order to wash off the bran and also any of the colouring matter which may be detached — 3 They are expond to the rays of the Sun for a considerable time

4th Next washed in rivulet of very pure water – 5th Then expound on a flat piece of ground covered with grass, called the bleaching green

6th Washed in a solution of Potash these two last operations are repeated 16 times the first 8 times the strength of the Ley should be gradually increased and afterwards gradually diminished

7th The Linnens are next laid in Bonny clabber – i.e. sour milk or sour butter milk, some use a diluted Sulphuric acid but this is too caustic

8th They are washed clear of this &c –

9th Washed clean in a solution of Soap

As it is our business to enquire more into the Philosophical than the practical part of the business, let us attend a moment to what happens in the above described process, In the first place the

Mixture of bran & Water, by their fermentation detach in a great measure the colouring principle of the Linnen, the second is to wash off the detached part of colouring principle and the bran & Water — the processes after those are to expose the Linnen in the air, that Oxigene may have access and also Light (both of which are active agents in destruction of colours) the use of Potash is to dissolve the colouring principle the sour milk or sulphuric acid completely destroys what little of the colouring matter remains

Potash is used in the manufacture of Glass & Soap, we shall treat of those substances in a more advanced part of our course — and now pass on to the consideration of —

Soda — the mineral or fossil alkali, so called because procured from the plants which grow near the Sea shore —

The Ancients appear to have some knowledge of it under the name of Nitre, Solomon

observes "The singing of Songs with an heavy heart is like the mixing of Vinegar & Nitre" If we understand by it the same Nitre as we now call so, it is nonsense for no action ensues upon the addition of Vinegar - but if we understand by it Soda, the simile is worthy that wise Man for a very strong action called an effervescence takes place —

Soda differs from Potash in the following particulars

1st It is much less caustic & fixing than Potash

2d It chrystalizes in octahedrons —

3d So far from deliquescing in the Atmosphere that it effloresces & spontaneously sublimes —

4 It is more proper for Vitrification and making soap —

Soda is procured by the same process as Potash, only instead of Wood &c. Marine Plants are used & their ashes lixiviated - In Asia especially near Tripoli it exists in very

great quantities - This imported also from Siberia Hungary & other eastern parts of Europe - It forms the basis of Glaubers & Marine Salt in the former it is united with Sulphuric in the latter with marine acid —

The Arabs were the first who obtained this Salt, their European neighbours in Hungary and other places near that, learned their process & made Alkali by burning all sorts of vegetables, but instead of soda they procured Potash. Mr. Boyle was the first who examined those two Salts, with any degree of Attention & found them essentially different from each other - Du Hamel and other Chemists confirmed his results, & they are now distinguished from each other - A cheap method of obtaining it from its combination with the marine acid has not yet been discovered, this a great desideratum in Chemistry - It may be separated from

Glaubers Salt by an intense heat in contact with Charcoal but this is also an expensive process - In England they procure it from plants which grow near the Sea, by the same process as Potash is procured - this Alkali is used in the Manufacture of spanish soap, it is preferable to the vegetable Alkali as the Soap is less caustic & dry, as it does not attract the moisture of the air - Its expense is the only reason why it is not brought into more general use - We might in this Country obtain large quantities of it from the plants which grow near Cape Henlopen - the acids do not so much corrode glass made of Soda as that made with Potash - more of this in its proper place ——

We are not yet acquainted with the constituent parts of Alkalis in as perfect a manner as could be wished, but there is no doubt

but they are compound bodies, and Mr. Lavoisier has consequently excluded them from the list of simple substances — Magnesia may by repeated calcination be obtained from Soda —

Ammoniac or the Volatile Alkali called also alkaline gas, and when mixed with water spirit of Hartshorn, because it was formerly prepared from Hartshorn — It agrees with the fix'd Alkalis with regard to the tests of common alkaline properties, but differs from them in its compounds &c — When mix'd with different substances or heated a suffocating odour arises, volatile and of a penetrating acrid quality, with oils it forms Eau de Luce — It precipitates the Metals from their acid solutions — If to a Nitric solution of Copper — This Alkali be added the liquor is turned to a beautiful blue colour, which the Ancients called aqua Sapharina, this by

evaporation affords Cuprum Ammoniacum - the Ammonia in this experiment precipitates the Copper and then redissolves it —

Ammonia is the produce of Animal putrefaction - Horsedung which has remained a long time in a stable so as to putrefy smells of of Alkaline when moved, this smell of putrid horsedung has been prescribed by Physicians to their patients but had they known that its virtues consisted in the alkaline gas it contains they might have prescribed it in a much more elegant form - The Ammonia procured in the usual way i.e. by burning hoofs horns clippings of hides &c always contains besides other impurities a black oil known by the name of Animal oil of Dippel —

The way in which Chemists procure ammonia is by distilling equal parts of quick

Lime & Muriate of Ammonia, taking care to place a quantity of water in the receiver to absorb the gas as it comes over, this is the common Spirit of Hartshorne, the characteristic smell is perceived as soon as the two substances are triturated together - If the muriate of Ammonia be distilled with Chalk which is a carbonate of Lime, the mild volatile alkali is produced in a concrete form. When the calces of metals are heated in alkaline gas there is a formation of water & the calces are reduced in this experiment, the hydrogene of the alkali unites with oxigene of the oxide and forms Water - The metal losing its oxigene is of course revived, and the Nitrogene gas remains, this experiment proves that volatile alkali consists of hydrogene & nitrogene According to Berthollet 180 parts of Azote and 93 of hydrogene form 273 of Alkaline Gas -

In the distillation of sal ammoniac & lime an elective attraction ensues, the Muriatic acid of the sal ammoniac unites to the lime and forms Muriate of Lime, while the alkali of the sal ammoniac unites with Calorie & escapes in the form of gas which is to be absorbed by water — When chalk is used a double elective attraction ensues. the Marine acid unites to the lime & forms Muriate of lime, while the carbonic acid unites to the ammoniac and gives it the concrete form of carbonate of a mild ammoniac

Mr. Lapina an Italian Physician having cut off the comb of a cock a very great hemorrhage ensued this he endeavoured in vain to stop, by accident a drop of the caustic volatile alkali fell upon the vessel and the hemorrhage immediately stopped this fact surprised him & he cut in the presence of some of his Friends the canal

Artery of a Sheep and this was likewise stopped by the Alkali, a Countryman likewise soon after applied to the Doctor with an alarming hemorrhage from the nose which nothing could stop here the stiptic was equally efficacious, in three hours the bleeding returned and the stiptic again relieved radically for it never appeared since – The next experiment was performed before a large meeting of the Royal Society, he amputated the thigh of a Goat and without using ligature stopped the bleeding in the same way, the King hearing of this useful discovery sent for Doc. Lapeira who waited on his Majesty with Doc. Vains and some other of his Friends, he proved the truth of the report & completely fulfilled his Majesty's expectations, the proportion which Doc. Lapeira uses in his famous stiptic is ℥iv of caustic ammoniac with 1℔ of Water

Ammoniac is the basis of some Collyria

× Dose of Caustic Spirit of Sal Ammoniac
10 a 15 Drops –

in the different Pharmacopeia as Aqua ammonia acetata &c &c — In their preparations it is of consequence that the ammonia be good & applied to the inside of the Eyelashes —

## Lecture 16th —

### Of Acids

They are known by the following properties

1st Their taste when diluted is sour.

2d They turn most blue vegetables to a red colour, Indigo is an exception to this

3d They produce heat when mixed with water & cold with Ice, there are exceptions to this rule

4th They unite with Alkalis with effervescence & form Neutral salts with them

5 They restore vegetable colours changed by Alkalis to their pristine colour, as turmeric turned brown by an alkali, the brazil wood paper turned purple by an alkali to

its pristine red colour &c – Tincture of blue cabbage is a very excellent test, it is turned green by Alkalis & red by acids – Syrup of Violets mostly contains Indigo & is therefore an improper test Radish scrapings also answer very well – Litmus or turnsole detects one grain of sulphuric acid in 100,000 times its weight of water —

The acids are all compound bodies consisting of Oxigene and some base —

Carbonic Acid called also cutaneous acid fixed air &c &c – called carbonic acid because it is composed of carbone & oxigene – fixed air because tho' it is a gas it is fixed in Marble Limestone &c – it is known by many other names as aerial acid &c – cutaneous acid because it is usually procured from chalk

We prove that it is composed of Carbone and oxigene because by burning carbone in oxigene fixed air is produced, thus it is proved synthetically, but it can also be analyzed by putting powdered marble which consists of the carbonic

Acid & Lime into a glass tube coated with a good Lute, to this Phosphorus must be added the the tube be hermetically sealed must be heated very intensely for some hours at the end of which time Charcoal and a phosphate of Lime are found in the tube now this is only to be accounted for by the decomposition of the carbonic acid of the Marble - Its oxigene unites to the Phosphorus forming phosphoric acid which dissolves the Lime and the charcoal of the acid is left in the form of a black powder - Doc. Black is said to have analyzed it via humida in his Laboratory in Edinburgh, by passing air which had been respirated by 2 or 300 students through Lime of Sulphur - This experiment I have never been able to succeed in tho' I have used Water impregnated with carbonic acid in the experiment ——

I might here mention Doc. Priestlys objections to this composition of Carbonic

Acid, he says he obtained by treating malleable Iron with red precipitate. I have recorded his experiment but have been as unsuccessful as in the last, to repeat the Doctor's experiment is needless, for any person may convince himself by burning Charcoal in pure air for Carbonic Acid is the result - this & the decomposition just now spoken of prove sufficiently the assertion concerning its component parts - The only way in which Doctor Priestly's experiment can be accounted for, is by his using cast Iron instead of malleable, in this case he has 16 times as much charcoal as in the other ℥i of Malleable Iron contains but one grain of charcoal -

The way in which carbonic acid is procured for Chemical experiments is by adding the Sulphuric Acid to Marble Chalk or Lime stone in coarse powder, the acid which exists in these substances is disengaged in form of a Gas which if required may be absorbed by water, Its properties are as follows -

1st It is heavier than Atmospheric Air, this property enables the Chemist to pour it out of one vessel into another in the same manner as he would a liquid, If you set a lighted candle in a Jar of Glass & pour the fixed air upon the flame it goes out instantly —

2d It is improper for Combustion or Respiration as Tapers are put out & Animals die when in this air —

Carbonic acid is disengaged in fermentation hence Van Helmont calls it gas Sylvestre of the Vintage or Must — It is found native and disengaged in some places as the Grotto del Cane in Italy, this is a small Grotto situate at the bottom of a Hill — the Carbonic acid covers the Earth for about the depth of three feet, Animals whose Heads are at a quarter distance from the surface of the earth than that may stand & respire with impunity, while low Animals as Dogs, Cats &c. die in

a very short time in it, hence its name of Cano from being fatal to Dogs, The Emperor Tiberius caused Slaves & Criminals to descend into it and be thrown on their backs so that they respired the Gas and consequently died —

In eruptions of Volcanos large quantities of it are formed, in a former eruption of Mount Vesuvius so large a quantity was discharged that the fishes were killed in the sea by its combining with Water —

It is also disengaged from Lime when it is calcined in kilns, also from brick kilns — there have been instances of Death to persons from sleeping near those places no doubt from this cause

Water absorbs more than its own weight of Carbonic Acid, this may be effected either by simple agitation or in an apparatus ~~invented~~ invented for the purpose by Mr. Nooth and improved by Parker & Magellan — Priestly is unjustly denied the invention

Nooth certainly improved it but Priestly as certainly is the original inventor -

It would be (says the ingenious Mr. Lavoisier) a great acquisition to be able to decompose this acid in a cheap manner, if this could be done vast quantities of Lime stone Marble & a hundred other Minerals in which it exists might be converted into Charcoal and be of great use in oeconomical pursuits, It cannot be done (says he) without the double elective attractions. for no substance has a stronger affinity to charcoal than oxigene consequently no substance would seize the charcoal from the oxigene - the other mode may possibly be used at a future time -

Bergman and others assert that carbonic acid so completely destroys the Irritability of Animals that they can never be resuscitated when destroyed by means of respiring this gas.

## Lecture 17th

Lake Averno where Poets place the entrance

to Hell disengages the carbonic Acid and Birds drop down & die when flying over this lake.

Some mineral waters consist of Carbonic acid & Water, these may be exactly imitated in Nooths apparatus, powdered lime is to be put into the lowest apartment and Sulphuric Acid (diluted) added, the gas escapes passes through a valve and is absorbed by the Water, Chalybeate Water may be imitated by suspending nails and Iron filings in this water ———

Water impregnated with Carbonic acid gives out the acid when it freezes or boils Bergman first noticed this, no is it says he difficult to account for it, for every one acknowledges the power of heat in overcoming the affinities by which bodies are united to each other, the colder water is the more acid it is capable of containing untill absolutely frozen, then it gives out all the gas which it held in

solution a rather suspension — Strong Beer when in a cold cellar is perfectly vapid but may be made brisk by bringing it to the fire when it suffers its carbonic acid to escape, hence the custom of Tavern keepers of putting their Porter & Ale in a Tub of warm water just before drawing the cask —

This Acid has been used with success in calculus diseases of the bladder, It has been considered as a very excellent diuretic Doctor Dobson says he thinks it has been of great service in those cases — De Fourcroy denies this, & says he has seen it used in a great variety of those affections with very little if any advantage (vide Dobson on fixed air)

Dobson also says he has seen it used in Cancers with advantage, Fourcroy also denies this the cases in which he used it, it appeared to do good for a few days, the sore discharged a less fœtid sanies appeared whiter and in

very respect better, but these flattering appearances went off and the usual Symptoms appeared with all their violence - Carbonic acid has been used in almost every disease to which the human frame is liable — Doctor Carmichael Smith used it in Dropsies as Ascites, Hydrothorax, Hydrocephalus Anasarca &c - Thornton Beddoes & Darwin used it in Dyspnoea, Thornton & Darwin in Chlorosis. in Calculus its virtues have been much celebrated, A Surgeon who cut 1400 Patients for the stone has assured that not one of them used malt liquor for their common drink, he thinks the Carbonic acid which exists in the Liquor would prevent their formation and even dissolve them when formed - Doctor Sydenham also thought it of great use in calculus & in the diseases of the Urine, he used never to ride out on rough

roads without taking first a draught of small beer, he says also that he drank just before and after he was in bed & just before composing himself to sleep it composed him wonderfully and prevented his complaint from troubling him Dr. Withering also used it for the space of many years, during which time he had but one fit of the stone which was owing to his leaving of the use of it for a considerable time

Doctor Johnson who graduated here a few years ago and wrote upon fixed air, had the courage to descend into a brewers Vat which contained beer in the act of fermentation he was in good health his pulse beating 84 strokes he respired the gas where in contact with the Atmosphere his pulse now rose to 100 strokes in a minute was bounding & irregular respiration difficult, perspired profusely — his blood vessels about the Neck, head &c tingid

with blood, and every symptom of the most violent Plethora, another curious circumstance which he noticed was an erectio Penis, during all this time his mind was perfectly composed, he enjoyed the use of all his senses, & could notice accurately the different changes which his feelings underwent — The intrepid experimenter Pilatre du Rozier immersed himself in this gas and felt all the above described symptoms excepting the last —

We pass to consider the combinations of the Carbonic Acid with Alkalis, and first with the vegetable alkali forming —

Carbonate of Potash, the fixed Alkalis as we described them always contain this acid unless it be separated by lime, Potash may be saturated with this acid by means of Nooths apparatus, a Solution of Potash is to be placed there, and Sulphuric Acid diluted with Water & chalk or marble must

be put into the lower chamber, the fixed air passes through the solution & is absorbed by it — This salt chrystallizes & is preferable to the common Potash as its causticity is completely destroyed — It is preferable in the antiemetic draught of Riverius which is compound of the Citric acid & this salt — Carbonic acid is the cause of the apparently fermentation which takes place in Bread, but which cakes therefore the more acid exist in Yeast the better the Yeast is — Carbonate of Potash is used in Calculus complaints tho' not so much as the Carbonate of Soda — It is made into pills for this purpose with soap or some other convenient vehicle and given in the dose of from ℈i to ʒi per day ——

Carbonic Acid & Ammonia forms the mild Volatile Alkali of which we have already treated ——

# Lecture 18th –

Sulphuric Acid, called als Oil of Vitriol or Vitriolic Acid, is composed of Sulphur and Oxygene and hence termed as above, called improperly Vitriolic Acid because it can be procured from Vitriol, called Oil because it feels oily this is owing only to the circumstance that it unites to the perspirable matter of the fingers – Its density also gives it the appearance of an oily liquor but it poss-es none of the properties of an Oil –

Its taste is saline, stiptic, and acid which is sour when diluted – It is found in combinations with many of the Metals particularly Iron, Copper & Zink forming Blue, Green & White Vitriol – the Acid may be procured by simple distillation from Sulphate of Iron – and according to Neuman and Margraef from Sulphate of Zink & copper

The most usual mode however of procuring it is from the combustion of Sulphur & Nitre – 1/8 Part of Nitre & 1 of Sulphur are burned in Chambers lined with Lead (the Nitre affords pure air for the combustion) the Sulphuric Acid is formed and absorbed by Water placed on the floor this is concentrated afterwards by distillation by this process the Acid which before was black, is rendered colourless ——

Three things are requisite in the formation of Sulphuric Acid –

1st A sufficiency of Oxigene

2d A close chamber to confine the vapours

3d A quantity of Water sufficient to absorb the acid ——

Mr. Berthollet asserts that 100 parts of sulphuric acid, contains 72 parts sulphur and 28 Oxigene ——

Sulphur possesses a stronger affinity to Oxigine than Nitric Acid, hence Sulphur placed in the Nitric Acid is converted into the Sulphuric Acid, the same happens if Sulphur be digested in oxigenated Muriatic Acid —

In the combustion of Sulphur the base of the oxigine Gas i.e. pure oxigene unites to the Sulphur & forms Sulphuric Acid while its heat and Light are set at Liberty —

Sulphuric Acid congeals with a moderate degree of cold, its chrystals in this state are regular, if a more intense cold be applied it resumes the liquid form —

It fuzes according to Dr. Priestly and some other Chemists more readily if combined with Nitrous Gas, this combination is effected by putting some zink or copper into Nitrous acid, and adapting a recurved tube to the vial containing it, one leg of the tube

conducts off the Nitrous air from the vial while the other leg conveys it through another vial containing sulphuric acid. the acid absorbs the gas as it passes through —

Sulphuric acid has a very strong attraction for Water and if exposed to the atmosphere attracts a large quantity from it and so becomes much diluted ——

Sulphuric acid is no wise volatile it requires several hundred degrees of Fahrenheit for its evaporation, when however it is heated sufficiently it evaporates and the acid is obtained in form of Sulphurous gas or Volatile vitriolic acid, this is capable of condensation by cold, and also of assuming the liquid form by combining with water - It colours litmus and the other tests red in the same manner as other acids, destroys animal Life, extinguishes a taper &c.

As the acid is more fix'd than Water it is

concentrated by evaporating the water - the Acid gas exposed to the Atmosphere absorbs six times its own weight of water - It is decomposed by oxiding Mercury, or burning Charcoal in it, according to Lavoisier, Dr. Fourcroy & Burquet - We shall further notice the opinions of these Gentlemen when we come to treat of Fulbith Mineral - Sulphurous acid gas forms with the alkalis the same salts as the Sulphuric Acid this is denied by many but such is the fact, for vitriolated tartar is obtained by exposing Potash to the Acid gas, and Glaubers Salt by exposing the mineral alkali - The usual mode of procuring the Acid gas is not by evaporation but by exposing a quantity of Charcoal to the Acid, this absorbs part of the oxigene and the Acid

Gas escapes in a less concentrated state —

Sulphuric Acid is never found in a disengaged state but always in combination the most of common of them are the three vitriols. Green, blue & white they exist in almost every part of the Earth. white vitriol has been lately discovered in Virginia — Sulphuric Acid combined with Lime forms Selenite. Gypsum or Plaster of Paris

Sulphuric Acid is of great use in Medicine & the Arts — In Medicine it is as a Tonic either simply diluted with water or in the form of Elixir of Vitriol combined with Aromatics. the aromatics I think are of but little use to it — The simple Acid given in the dose of 30 a 40 drops per day in sweetened water makes an agreeable Beverage — Externally applied it is a very excellent remedy for the Itch

and other Cutaneous disorders, far preferable to the Vegetable Acids —

Ingenhouz moistened plants with it and found them thrive much better for it — In the Arts it is used in dyeing in large quantities — It is the proper Solvent for Indigo the blue dye of this City is nothing but a solution of Indigo in this Acid — Ladies colour ribbons with it and Bookbinders colour the edges of the leaves of Books —

## Lecture 19th

Our next subject is the combination of Sulphuric Acid & the Alkalis & first of the Sulphate of Soda or Glaubers salts but before proceeding to the immediate object of the Lecture we will make a few observations concerning compound salts, these are compound of two simple salts as Acid

and Alkali Earth Metal &c — When neither the Acid nor Alkali predominate they are called Neutral Salts, if the Alkali predominates they are called Alkaline, the Acid they are called Acidulous &c — In neutral Salts we find neither of the properties of its constituent Parts, Thus the Salt about which we are just going to treat possesses neither the Acid taste of the Sulphuric acid nor the uninous taste of the Alkali

Disputes have arisen concerning the proper method of ascertaining whether the Alkali and Acid are both in equal ratio & saturated some apeal the Taste is the only proper criterion for judging, This is far from being an exact way of determining, some have been content with observing when the effervescence ceases this also is a precarious mode, the most accurate method in my opinion is the tests for Acids and Alkalis

a tincture of blue cabbage answers very well for this purpose as Acids turns it red and Alkalis green —

The properties of Neutral Salts are

1st They possess an acid taste more or less in degree — 2d They have no action on inflammable substances as sulphur charcoal &c

3d They have no action on the Metals

4th They are not changed by Water which simply dissolves them tho' no decomposition or change whatever ensues these properties are owing to the affinity subsisting between the component parts of the Salts, being greater than that of either of those components parts to the different substances enumerated, this being premised you will not be troubled to understand what you will hereafter hear concerning different Neutral Salts —

Sulphate of Soda called also Glauber Salt - Sal admirabile &c. - This chrystallizes in beautifull octahedrons, two of whose angles are acute & two obtuse when exposed to the air it effloresces, the powder of Glauber Salt must be given in much smaller doses than the Chrystals as the latter contains much water, which adds considerably to their weight, some have even said that the chrystals contain one half water —

The effects of Mixture on this salt are

1st Acids do not act upon it —

2d Alkalis have no action whatever upon it —

3d It has no action on the Metals —

4th - Ignited charcoal decomposes it, the oxigene of its sulphuric Acid unites to the coal & forms Carbonic acid while the Soda and Sulphur remain —

The effects of heat are, that by a gentle heat it undergoes the watery fusion i.e. the Crystals contain so much water as when heated to dissolve the salt for hot water dissolves a very great deal more of almost any Salt than cold —

We said that Acids have no action on it, but Mr Baume says he has decomposed it by highly concentrated Nitric Acid, We also said that it does not act on the Metals (in their simple state) by means of a double elective attraction the Salt may be decomposed, it is very soluble in Water, hot Water dissolves its own weight of it —

As to its natural history, it is seldom found in a native state, it has however in old brick walls, and efflorescences of it have been found on the surface of the Earth

especially at Astracan in Asia, Bohemia and Switzerland in Europe. It exists in many Vegetables. Authors say large quantities of it may be procured from the Tamarix Gallica — Chaptal informs us that all the Glauber Salt which is used in the Southern parts of France is obtained from this plant in the same manner as the fossil Alkali is from Kali —

It is most commonly procured from different Salts either by single or double elective attractions, and also by mixing the components parts. Pure Soda & Sulphuric Acid. the last method is proposed by a Society at London —

By single elective attraction. It is sufficient to add sulphuric acid to common salt, the Sulphuric displaces the Muriatic acid & unites to the Soda, while the latter escapes in the form of fumes, those

The method of making this salt in Europe at present is by adding the Carbonate of ammonia procured by distillation from Animal substances to Gypsum a double elective attraction takes place and we have the Sulphate of Amm. and Carbonate of Lime. The Sulphate of Ammonia is seperated from the carbonate of lime and added to ~~common~~ salt another double elective attraction takes place and we have the Muriate of ammonia and Sulphate of Soda.

who are acquainted with the Attractions will find a great number of methods of forming this Salt but it is needlessly for me to mention them, one however I propound to the Chemical society of this City, it is to add Gypsum to common Salt a double elective attraction ensues instead of Muriate of Soda & sulphate of Lime, we sulphate of Soda & Muriate of Lime +-

Sulphate of Potash called also Sal de Duobus, Arcanum Duplicatum & Vitriolated Tartar, this also undergoes the Watery fusion by a moderate heat - the addition of Acids have no action on this Salt when heated in contact with Charcoal it is decomposed, as the former, Metals in their simple state have no action upon it, it is soluble in 16 times its weight of water It has no action on Vegetable nor Animal substances, It is found native in certain plants

It exists in large quantities in the Tobacco
Nitre has been said to exist in this plant
but this is owing allogether to its putrefac-
tion in Ware-houses, the salt is vitriolated tartar
Four methods are in use of obtaingin this Salt
1st By mixing the disingaged Acid and
Alkali together
2° By mixing the Acid in a disingaged
state to the Alkali in combination with
foreign substances, this is done in the dis-
tillation of Nitrous Acid by adding Sulphu-
ric acid to Nitre - the Sulphuric Acid unites
to the Potash while the Nitric Acid is disinga-
ged — 3° By mixing the Acid in a compound
state with the alkali in a simple uncom-
bined state - thus Glaubers Salt is decom-
posed by Potash, the Acid & Potash unite
while the soda remains pure -
4th By double elective attraction - If
to any Salt which contains Potash

you add another which contains sulphuric acid you obtain this Salt —

The first of these processes being too expensive is seldom used. The 4th is liable to the same objection the 2d & 3d are the most common. Green Vitriol & Vitre heated intensely yield it —

Sulphate of Ammonia or Glaubers secret Ammoniacal Salt is compound as its name indicates of Sulphuric Acid and the Volatile Alkali, it has a bitter pungent penetrating taste, fuses & evaporates when heated without decomposition — If fused with Sulphur a substance which very much resembles Hepar Sulphuris is formed. It acts on all the sulphates & some of the calcs of the Metals if heated in contact with them it evaporates carrying them along (especially copper, but also Iron, Zinc, Tin, & Lead) This circumstance induced Glauber to call

it the Eagle Salt he compares its Acid to the Eagles talons with which it seizes any substance & the Alkali to its wings with which it flies away, Glauber thought very highly of it & used it in a great variety of diseases

This Salt is sometimes tho' rarely found in a native state in the Neighbourhood of Volcanos, but is most prepared by the elective attractions as directed in the 2d & 3d methods for making the last described salt but if wanted in a state of great purity the Caustic alkali should be added to pure Sulphuric Acid & chrystallization be performed

This Salt dissolves Silver after precipitation from Aqua Regia ——

Nitric Acid – this like the Sulphuric Acid has several Names, Aqua Fortis, Spirit of Nitre, &c &c – like that Acid

is seldom if ever found in a native state but is extracted from its combinations by Chemical processes, the most method of obtaining it now is to separate it from its union with potash by the addition of Sulphuric Acid, the common direction of Writers is to add 1 part of Sulphuric acid to 2 of Nitre, but I always use equal parts as the residue in the retort which consists of vitriolated tartar is very difficult to get out unless in a liquid form - In works in the large way 1 to 2 May answer - the mixture in either case must be distilled the Nitric acid rises in a very concentrated form and is condensed in the receiver - this an example of distillatio per Latum -

## Lecture 20th

Nitric Acid consists of 7 parts pure Air & 3 of Azote M. Cavendish by putting the

proportions of the two airs into a copper tube and receiving several thousand electric sparks through them converted them into Nitrous acid – Doctor Priestly objects to this and says that he has procured Nitrous Acid from the explosion of Hydrogene & oxigene gases by the Electric spark. the experiment I have have performed & from 58 ℥ measures of those airs I procured two grains of the Acid, now so much air could not be employed in the formation of so little Acid, I am certain that it was owing altogether to the small quantity of Azote which the pure air contained for the purest oxigene gas always contains a sufficiency to account ~~to account~~ for this small quantity of Nitrous Acid

Mr. Weir a Gentleman who analyzed Doctor Priestly's Gases after the explosion

thinks that a small quantity of Marine Acid existed in the Liquor - now this must have been owing to impure water in his Pneumato Chemic tub. (pump water always contains marine acid) ——

This Acid was generally thought to belong to the Mineral Kingdom exclusively - but this is not the case for Doctor Mitchell professor of Chemistry in Columbia College, New York has obtained Nitrous Gas from organized Animal matter, we know that the two elements Azote and Oxigene form the organic texture of our bodies & we know that after Death a Chemical combination of the two takes place (viz from the experiment of Chaptal & others who obtained Nitre by exposing Potash to the effluvia of Animal matter in putrefaction)

Ī Becher obtained from the excretions of

Animals in putrefaction tolerably pure Nitrous Acid, with this object in view he exposed the Urine of Cows for the space of 8 days to the Air, so as to let it undergo the putrefactive fermentation after this he obtained Nitrous Acid from it

3rd He concludes that the Salt & Nitrous Acid which are obtained from the Earth under stables & Cow-houses are owing to the putrefaction of Animal excretions —

4th Subsequent Chemical experiments has confirmed Becher's results - for Nitrous Acid & Salts containing it are often procured from the Earths of Stables & Cow houses —

5th Boerhaave & Maquer have obtained pure Nitric Acid from Animal substances this last even asserts that they are better calculated for this purpose than either Vegetable or Mineral substances — —

6thly — Mitchell himself has experimented and finds that Nitrous Acid can with great ease be procured from Animal putrefaction and has in consequence of this called Azote Septon — and has consistent with the rules laid down in the New Nomenclature, formed a list of names for the combinations of it with Oxigene and various substances —

Thus Septon expunges Azote

| | |
|---|---|
| Septous gas | Nitrous air |
| Gaseous oxide of Septon | Nitrous Acid Gas |
| Septous Acid | Nitrous Acid |
| Septic Acid | Nitric Acid |
| Septate | Nitrate |
| Septite | Nitrite |

This scheme has been objected to & I think with some reason for tho' I firmly believe that this Acid is the product of putrefaction yet I believe it can and is generated without

that process. Near Madrid in Spain Nitrous air is generated by a heat of 96° and a calcareous soil & no putrefaction goes on there

Nitric Acid added to Muriatic acid forms Aqua Regia, called in the new nomenclature Nitro-muriatic acid. called Aqua Regia because it is the only Solvent for Gold the King of Metals. Chaptal says the reason it dissolves gold is owing to the facility with which one of the Acids bride the Metal after which the other dissolves it tho' some say the oxigenated Muriatic acid is formed by the Marine acid attracting the oxigene of the Nitric - this point is undetermined - the probability is that oxigenated muriatic is formed. 1st Because during the Mixture of the two Acids there is an escape of oxigenated muriatic Gas as may be distinctly smelled - 2 We may prove

that Muriate of Gold is formed, because if a saturated solution of the Gold be made & Alkali added we obtain the Nitric acid in combination with the alkali used if Potash we procure Nitre, if Soda cubic Nitre and if Ammoniac Nitrous Ammoniac ——

Nitrous Acid acts on some of the Earths tho' not all, Strontites is not attacked by Nitric Acid unless diluted with Water, nor does Nitric Acid act on all the Metals, Tin Copper, Silver & Bismuth resist its action till Water is added, when this is done they are instantly dissolved, this fact has entirely escaped the Notice of the French Chemists they say the concentrated Acid acts on all the Metals — Nitrous Acid acts very powerfully on Oils, the more oxigine the oil contains the stronger is the action of the Acid hence the drying oils are preferred as they contain an immensity of pure Air ——

If a quantity of concentrated Aqua Fortis be suddenly thrown upon three times its weight of oil of turpentine the oil instantly inflames and is consumed — The process of Rouelle is to use equal parts of Sulphuric & Nitric Acid with 3 parts of Oil of turpentine it must be poured at usual times upon the oil — This is a very precarious experiment if the air is damp or cold it will not succeed the vessel must be warm & dry in which it is performed — Mitchell has verified this experiment in the following lines —

You saw that time terrific Anger boil
When Aqua Fortis met with heated Oil
Both vanquished falling underneath the stroke
Expired in flame and suffocating smoke.

Nitric Acid likewise acts upon Charcoal in the same manner the Charcoal must be very finely powdered & very free from moisture the Acid must be highly concentrated, slightly warmed & poured drop by drop down the side

of the vessel (for if poured in the middle of the coal no action at all ensues) — If the above precautions be used and (either with lampblack or common charcoal) the action takes place the oxigene gas of the acid is decomposed, its heat and Light being disengaged —

According to Mr. Fourcroy the coal which is made in the Evening will not succeed in this experiment the next day as it absorbs water from the Atmosphere — this same Philosopher performed the experiment in a retort to ℥i of dry charcoal in impalpable powder he added an equal quantity of Aqua fortis the Charcoal inflamed and a stream of fire issued from the Beak of the retort 4in. long in an open mouthed vessel the coal is thrown up like a beautifull rocket —

Doctor Priestly has communicated an account of the Gases disengaged in this expe-

iment to the American Philosophical Society he says it consists of Phlogisticated air, but he is most certainly mistaken or else he used water in his experiment for such gas escapes in the experiment unless water is used and not always then —

This Acid unites with all the Metals but Gold, Brandt even asserts that it acts upon this Metal, Kirwan opposes him in this —

It dissolves Silver forming Lunar Caustic

It acts on Copper (if diluted) In performing this experiment an hundred times, I have always observed a curious fact which I dont recollect to have heard explained, I mean an escape of very highly coloured Nitrous Air which possesses some of the properties of Oxigene, it rekindles a taper as frequently as pure air — the flame of a candle is as much enlarged in it as in pure Air, Now to account for this circumstance I am totally at a loss —

In every solution of a Metal in this Acid its Oxigene oxides it first & then dissolves it as it loses its oxigene a gas escapes which is Nitrous acid deprived of part of its oxigene it is known by the name of Nitrous Gas –

It procured usually by placing some small pieces of Copper, Zink or Mercury in a retort adding diluted Nitrous acid and receiving the gas through water if it comes in contact with the oxigene of the Atmospheric air, Nitrous Acid is reproduced & the colourless & transparent Gas acquires a red colour – It is best always to use a small retort and have it filled with the acid & water, for when the disengagement of gas begins Nitrous acid is reproduced by the air combining with the Oxigenous gas of the Atmosphere, an absorption immediately takes place and a partial Vacuum is formed the cold water now rushes into the

Retort and infallibly cracks it —

Nitrous gas possesses the following properties

1st It is perfectly colourless and transparent

2d – It is neither acid nor Alkaline as it has no action upon blue Cabbage —

3d It invariably acquires a red colour and acid properties when it comes in contact with pure air, this as we before observed is owing to a reproduction of the Nitrous Acid –

4th It is improper for Respiration & Combustion

These properties vary as it is obtained from different substances and is of different degrees of purity – The various Metals require different quantities of pure air for their solution & of course the gas must contain different proportions of oxigene – that from Tin contains most Oxigene says Kirwan —

Lavoisier by distilling Mercury & Nitrous Acid procured Nitrous gas & the Metal was oxided, hence he concluded that a portion of the oxigene of the Acid united with the Metal & oxided it, while the Azote of the Azotic Gas remained in combination with some of the oxigene and constituted Nitrous gas

2d This same Gentleman has ascertained that Nitrous Acid is compound of about 13 parts of Water 2 of pure Air & 2 of Azote, he concludes that Nitrous Acid contains more oxigene than Nitrous Gas —

3 That the more oxigene the Acid contains the more ready will be the combination with the Metal &

4th Of consequence metals have a stronger affinity with Oxigene than Azote has —

# Lecture 21st

Nitrous Acid may be proven to consist of Azote & Oxigen as aforesaid — 1st By exposing Liver of Sulphur or Sulphur & Iron filings to an Atmosphere of this Gas, the Oxigen will be absorbed and the Azote will remain behind —

2 — By placing an inflammable substance in an Atmosphere of the gas & throwing the focus of a burning Lens upon it during combustion all the pure air will be absorbed and the Azote left

3. By passing Alkaline gas through a Gun barrel ignited to redness & containing the black oxide of Mangnise, in this experiment the Azote of the Alkaline gas unites with part of the oxigen of the oxide of mangnise and forms Nitrous Acid, while another portion of the oxigen unites to the Hydrogen of the Alkali and forms Water —

Thus then in spite of Dr. Priestly's

objections the composition of Nitrous Acid is proven both by analysis & synthesis to consist of Pure Air and Azotic —

An absorption takes place when Nitrous gas is mixed with oxigene and also a production of heat, these circumstances are owing to the circumstance that the Nitrous Acid which is generated approaches more nearly to the liquid form than the Nitrous gas bodies you know passing from a fluid to a solid, or a Gaseous to a liquid state give out heat, 30° of Farenheit are generated or rather evolved in this experiment — the temperature of oxigene which before mixture with Nitrous Air at the same temperature was 40° rose when added to Nitrous air to 65° — The absorption which takes place is proportional to the quantity of oxigene and hence the Eudiometer is constructed —

This Instrument is compond of a tube of glass closd at one end, to which is adapted a scale at its upper end divided into 200 equal parts a Vial is procured which contains exactly 100 of those measures of air Water &c when the Eudiometer is to be used this vial is filled with the air to be examined and the vial-full of air is put into the tube it then occupies 100 parts, an equal quantity of Nitrous air procured from Mercury Copper or the like and Nitric Acid is added, an absorption of the reproduced Nitrous acid by the Water instantly succeeds and this in proportion to the quantity of the oxigene gas present ——

1. 100 parts of Hydrogene gas being introduced with 100 of Nitrous air occupied 200 Degrees no absorption took place — —

2 Pure oxigene gas obtained from Sulphuric acid and very pure black oxide of Manganese yielded an absorption of 170° the purest oxigene which

has yet been obtained yields an absorption of 195°. so that instead of occupying a space of 200° they only occupy 5° —

3. Common Atmosphere in this Labaratory yields an absorption of 70°. it contains much fixed air from our Lungs & the furnaces, when this is the case it may be detected by filling the tube with lime Water and agitating it ——

This instrument is very inaccurate for Nitrous gas itself often undergoes an absorption of 20°. — Doc^r. Davidson of the West-Indies has been engaged in some experiments on air and has fallen into many errors from the inaccuracy of this instrument and many other Chemists have been as unsuccessful, owing to this same cause ——

The Abbe Fontana says he has made Nitrous air from the same Acid the same Water the same Metal in the same vessels nay what is more with the same degree of heat and at the same time, differ in their

absorption with the same oxigene —

Nitrous gas is neither acid nor alkaline tinctire of blue cabbage agitated with this gas is not altered in colour, but the instant a sufficient quantity of oxigene is added it is reddened —

Nitrous gas may be absorbed by Alkohol by alkaline liquors & Charcoal, if Olive oil be agitated in it, it is coagulated —

Doctor Priestly has made some experiments upon the red colour of the Nitrous Acid, he thinks it is owing to heat, for he heated some limpid Nitric Acid in vacuo & found that its colour was become red in the same manner as in the air —

Nitrous Acid hardens oils e.g. the Unguentum Citrinum of the shops is prepared by a Nitric solution of Quicksilver & Hogs Lard, the addition of the Nitric solution hardens the Lard to the consistence of tallow or wax —

Mixed with water it generates heat, with Ice or Snow a most intense cold, in this it resembles the Sulphuric Acid —

Doctor Priestly denies that Nitric Acid with Zinc yields Nitrous Gas, but this is demonstrable by experiment ——

## Lecture 22d —

Let us next attend to the natural History of this Acid — It is never found native and uncombined but ~~must be~~ separated from substances in which it is a component part — 1st It may be and most commonly is by Chemists from equal parts Nitrate of Potash and Vitriolic Acid by distillation —

2d By distilling Nitre & Argillaceous earth in powder, or powdered flint or sand — in this operation a most violent heat is required & the acid produced is very good & pure — (if the material were such) The Clay or Sand

Acts by aspirating in detaching the Alkali forming Glass with it, some direct to add water to assist the volatillization of the Acid but this is a bad practice as it dilutes the acid, it would be better to deprive the Nitre of all water and this is actually done by drying in furnaces in large works —

3d - By distilling Green Vitriol (i.e. Sulphate of Iron) with Nitre, an intense heat is also requisite here, If an intense heat be not used a double elective attraction infallibly ensued, the Nitric acid of the Nitre unites to the Iron and the Sulphuric of the vitriol to the Potash forming vitriolated tartar - the same caution taken notice of in the last method applies here viz. to deprive the Salts of their Water of Chrystallization by means of heat, some ignite the green Vitriol to whiteness and some to redness

no material difference is perceived in the product — According to Scheffer the best proportions are 40 ℔. of Nitre to 50 ℔ of green vitriol, if in the operation any Sulphuric Acid rise it must be separated by cohobation (a long digestion in a particular sort of still for a description of which see Nicholson's Chemical dictionary) If Marine Acid it is separated by a Nitric solution of Silver, this forms a white muriate of Silver called Luna Cornea — The cheapest mode of detecting Sulphuric Acid is Barytes this very accurate detecting very small quantities of the acid ——

Nitric Acid has lately been used in Syphilis by Dr. Scott of the East-Indies he says it salivates & is a very good substitute for mercurial preparations, he says its action on the Mouth & fauces resembles very much that of Mercury, hence he

infers that as Mercury contains much Oxigene in the usual forms in which it is exhibited Salivations are owing to oxigene, this is absurd Mercurial ointment cantains very little if any oxigene and what produces a more speedy or violent salivation than mercurial ointment, the blue pill made by rubbing Mercury and Rhubarb contains very little oxigene & yet the blue pill salivates again one ounce of concentrated Nitric Acid contains more oxigene than a pound of Calomel and ought to produce a more speedy and violent salivation yet experience denies that this is the case ——

Doctor Scott has observed a kind of Fever to arise from the use of Nitric Acid rabs all over the Body - evident febrile symptoms about the 15th day after begining an extraordinary Increase of the sense of smelling, He thinks that these Symptoms

seize the Malays & Natives more than Europeans. They are more susceptible when the patient lives on animal than when on vegetable food —

Dr. Scott has proposed & tried with success Nitrate of Alumina he finds this to salivate as speedily as the Acid — He also used a Mixture compound of ℥vii of Manganese to ℥i of Nitric Acid, the Acid used must be very strong for ℥i of weak Nitrous Acid contains not more than ʒʒ measures of pure Air whereas ℥i of concentrated Nitric Acid contains 30 or 40 ℥ measures

Dr. Mitchell has speculated ingeniously & formed a Theory, that Nitrous Acid in the Atmosphere is the cause of Yellow Fever, the Contagion of small pox, Syphilis, Plague, Measles and in short every contagious disease — Dr. Mitchell is sometimes inconsistent in his conjectures

conceiving sometimes that too much oxigene & at other times that too much azote is the cause of their pestilential diseases (see Medical repository of N. York)

It is really curious to observe the various & diametrically opposite methods which different people take of Philosophizing - While Dr. Mitchell is thus endeavouring to draw us into a belief that Nitrous gas is the principle of contagion Doctr. Carmichael Smyth on the other hand endeavours all in his power to persuade us that it is a complete preventative & cure for all sorts of pestilential effluvia & an antidote to all contagion - Dr. Smyth impressed with this belief, orders some of his patients to add oil of Vitriol to an equal weight of Nitre, he says in Hospitals & Jails

it would be of great use in the Summer season – He caused two Young Gentlemen to remain in an atmosphere of this air and they suffered no inconvenience – Dr. Smyth is most undoubtedly mistaken here for no person can remain with impunity in an atmosphere of this Gas – you must all of you have observed the difficulty with which you are able to remain in a Room in which a Metal is dissolving in Nitrous Acid owing to the fume which are disengaged now these fumes are nothing but Nitrous Gas ——

Doctor Mitchell has a wrong Idea of the air which exists in our intestines he supposes it is the Dephlogisticated nitrous Air of Doctor Priestly, but it is entirely Sulphurated Hydrogen Gas, probably containing a small quantity of Phosphorus ——

# Lecture 23d —

We pass next to the combinations of the Nitric Acid with the Alkalis and first of Nitrate of Potash, Nitre or Salt Petre it is composed as its name denotes of Nitric Acid & the fixed vegetable Alkali, as this substance is very interesting, both on acc of its extensive use in the Arts and also as a very useful Medicine we will stop to say something of its general properties and uses —

Nitre fuses below a red heat (the watery fusion) if the heat be further urged it is volatilized & decomposed the Oxigene of its Acid being set at liberty, vast quantities of pure air may be thus obtained from Nitre. 1lb of it yields 12000 ⅔ measures of Oxigenous gas, a small quantity of Azote however always accompanies this pure Air — Nitre chrystallizes in

beautiful hexahedral prisms, it promotes the fusion of refractory ores & earths & therefore forms a constituent part of most fluxes which are used for this purpose. It detonates when thrown upon ignited charcoal & is decomposed with a spluttering noise, in this experiment the oxigene of the Nitric acid unites to the coal & forms fixed air or carbonic acid while the Azote is dissipated, the potash is left and may be procured by lixivation — This explanation is just for no detonation is produced by heat unless the Nitre be in contact with an inflammable body as phosphorus, coal, Sulphur &c - the acid of Coal, of Phosphorus, of Sulphur &c being formed in the experiment prove that oxigene must be present, and as the alkali of the Nitre remains after detonation and no smell of Nitrous gas is perceived we

infer that its acid is decompound – We prove that oxigene does not come from the Atmosphere by performing the experiment in vacuo which has been done — The vast quantity of Oxigene which Nitre contains has given rise to its use in the manufacture of Sulphuric Acid —

Nitre combined with Sulphur & Charcoal forms Gunpowder — Much has been said for & against the utility of this invention many have asserted that Mankind had been happier without any knowledge of this invention, while others have asserted that its use has overbalanced its mischievious consequences, for my own part I confess, I think the invention of Gunpowder has been of great use to Humanity Wars since the use of this substance have been much less frequent and destructive

It has put Enemies upon a more equal level than they formerly were — The rich cannot now avail themselves of a coat of mail, or other expensive mode of defence - numbers do not now give such a decided superiority as formerly — If to this we add that strength cannot now triumph over weakness, nor the large Man over his diminutive foe we are indeed to give a decided preference to the use of Fire Arms — Calculations have been made which prove that not more than one ball in forty does execution at the ordinary distance for firing —

Mankind early adopted this mode of settling National disputes, and of course the Lance, the Sword, the Spear, the Battle Axe have yielded to the more effectual operation of the Rifle, the Musquet &c —

As to its invention — Some have

pretended to have it to a very early period but the only certain information we possess with regard to this subject gives the honour of the discovery to Friar Bacon, tho' a German by the name of Bartholt Schwartz who discovered it tho' at a later period, he having occasion to expose to heat a mixture of Charcoal Nitre & Sulphur in some Chemical experiment, escaped narrowly with his Life, from a most violent explosion which took place as soon as the mixture was sufficiently heated — He took the hint however and improved upon it till he made some Gunpowder — He published his discovery to the World, a discovery which threatened at first the annihilation of the whole human species but which has in my opinion been of great use to it But as we before observed tho' Bartholt Schwartz was the first who published

this extraordinary product, yet we have proofs that a knowledge of it existed in earlier ages Marck the Greek appears to have had some knowledge of it, and Bacon did certainly know its composition, he mentions in his Writings the Sulphur & Nitre but conceals the Charcoal in an Anagram —

"Sed tamen Salis Petræ, lure mope can ubre, et Sulphuris, et sic facies tonitrum et coruscationem, si scias artificium"

The words lure mope can ubre, are an anagram of Carbonum Pulvere — Friar Bacon adds that he thinks by some such artifice as this, Gideon defeated the Mediamites with only 300 Men —

Nitre used in the manufacture of Gunpowder should be very pure, this is not sufficiently attended to, the Nitre used in our powder works often contains a portion

of common Salt, which detracts much from the good quality of the Powder — Calcareous earth with other impurities also exist in it —

Charcoal is an essential part of the composition, the charcoal used in it is commonly procured from the lightest wood, but Mr. Baume a Prussian Chemist, asserts from experiment that heavy woods afford coal equally well adapted to the manufacture of Gunpowder, but Coal procured from Animal matter does not answer at all for this purpose and is never used ——

We have little to say concerning the Sulphur it should be as pure as possible

Good Gunpowder should possess the following properties —

1 It should explode the moment it comes in contact with an ignited body —

2 Should leave no unconsumed residue behind but be totally burned — The

first depends on the accuracy of the mixture and the second on the proportion of the ingredients, this proportion is said to vary in different countries, how this is I dont pretend to determine, the proportions used here are 6 parts of Nitre 2 of Sulphur & 1 of Charcoal, they must be mixed & triturated in a wooden Mortar with a wooden pestle or in a mill contrived for the purpose for a space of 12 hours; care must be taken to moisten the powder from time to time not only to prevent the finer parts from being dissipated, but also to prevent an explosion from the heat generated in the trituration - When this is done the powder is carried off to be dried either in the Sun or in a room heated by stoves this latter is always dangerous ——

The powder thus made is in the proper state for use, excepting that it is very apt to blacken any thing with

which it comes in contact and adheres to the sides of the Fire arms, to remedy this inconvenience, a process has been contrived called graining it consists in sifting the powder while moist through a leather sieve a block of Wood is laid on the top of the sieve and it is agitated till all the powder has fallen through — This powder is used for Military purposes but that used for fowling still undergoes another process called Glaizing, this done by half filling a small cask with powder, this cask is fixed upon two pivots one at each end and it is rolled round & round till the powder is glaized, this operation serves only to break the small angles off from the grains and give them a smooth glassy polished appearance. the grained powder is sifted from the dust and is fit for Fowling or Hunting &c ——

Then two last mentioned processes add nothing to the detonating property of the powder – the first indeed granulation detracts much from it for the water which is added crystallizes the Nitre and so deprives it of the accuracy of Mixture which it before possessed — Let us now enquire how the effect of detonation is brought about ——

In the first place the oxigene gas being (by the heat of the spark) set at liberty from the Nitre. this unites to the Charcoal forming Carbonic Acid in the Gaseous state, on the other hand the Sulphur unites with the Alkali of the Nitre and forms with it a true Hepar – this hepar disengages sulphurated hydrogene gas – the above gases Sulphurated hydrogene & fixed air meeting in an instant are exploded by the decomposition of the fixed Air. i.e. the Oxigene gas of the Carbonic acid is set at liberty and unites with

Hydrogene forming Water in the state of vapour endued with great force of expansion the Air of the Atmosphere uniting the expansion, an explosion is the consequence —

As Nitre forms the basis of most exploding compositions we will next consider the Fulminating Powder composed of 3 parts of Nitre 2 of Potash and 1 of Sulphur, these ingredients being mixed well and ℥i of the powder being heated on a stove or shovel very gradually, the mixture turns brown, fuses and explodes with a loud noise, when the mixture is fired an ignited body assists the explosion — In this explosion Liver of Sulphur is also formed and a sufficiency of pure Air is emitted by the Nitre to account for it ——

It has been thought and is still that Nitre is the basis of the famous Greek Fire of Antiquity — This curious substance whose

composition is still a secret was invented by Callinicus an Engineer of Heliopolis a City in Syria Anno Domini 660 it was then used by the Greeks against the Saracens in a Sea fight commanded by Pigonates near Cyzacus in the Helespont —
It is described as being of a liquid form, if projected in the Air it never could be diverted from its first course Pigonates used it with such success in this expedition that he destroyed the Enemies fleet & 30,000 Men —
Water had no power in quenching it and checked its progress, but Vinegar with Urine and raw hides could only put it out. It was thrown in vessels of glass on board the Enemies Ships —
The Greek fire was afterwards used at the Seiges of Acre and Constantinople

Joynville a french Officer who assisted at the seige of Acre describes it with wings like a Dragon and a flaming tail like a broad Sword — When the Soldiers saw it in the Air they fell flat on their faces and prayed fervently to God to preserve them from so terrible an enemy

It is probable that Oil of turpentine and petroleum are component parts of it

It is said that a Chemist by the name of Grofs now enjoys a pension in Geneva for keeping secret a composition similar to that of the Greek fire —

Nitre promotes the fusion of Ores & Earths, hence it is used in fluxes for this purpose - it has this action only in consequence of the pure air it contains

Its property of vivifying Metals and

Seperating the base metals from Gold, has caused it to be much used by Alchemists —

We find in the Writings of Basil Valentine (a person whose writings are strongly tinctured with Alchemy) Nitre introduced speaking in a very pompous dialogue — When by myself a Batchelor I am capable of doing nothing but must be married therefore I take Venus to be my wife (Venus is an Alchemical term for copper) Venus unlike the generality of Wives is a charming complaisant Woman, when united we beget Children which live to enjoy the fruits of our mutual Labours — meaning that Copper and Nitre when properly united beget Gold — This Idea is taken from the use of Nitre in Agriculture, Nitre he thought would assist to extract Gold (the seed of Metals)

in the same manner as it does the seeds of vegetables, for the Alchemists believe that Gold is a principal which exists in every Metal changed & modified in a thousand forms by being mixed with various impurities

## Lecture 24th

When fused with an equal quantity of Sulphur forms a substance known by the name of Chrystal Mineral - In other proportions it forms

Nitre is much used in Medicine as a diuretic, it has lately been used by Doc. Wood in cases of Typhus and other chronic diseases with success he supposes it acts by giving out its oxigene in the System but this Idea is absurd, for a red heat is requisite for this purpose

Nitrate of Soda or cubic Nitre is

~~2.nd By adding a solution of potash of the shops to a solution of Common salt~~

compound of Nitric Acid and fixed fossil Alkali, we have little to say of this Salt - it Chrystallizes in Rhomboids or irregular cubes, hence its name, it is never found native, but is made usually by a direct combination of the Acid & Alkali

We pass on to the natural history of Nitre

Chemists tell us that Nitre is the uniform product of putrefaction, It is often obtained from Animal & Vegetable offals but is seldom if ever found native - the preparation of it is no longer confined to the East Indies, but Europe participates in it

Cramer a Chemist of note in Germany gives us the manner in which it is prepared Earth is mixed with Lime sifted, then is moistened with Urine, put under a shed & stirred daily, this shed is well covered and

has a window open at the North east end — this is not because they suppose the North West Wind is impregnated with any Nitrous Particles because the air from that quarter is of the temperature which suits best with the production of Nitre, after it has remained in this house for two Months it is sufficiently impregnated with Nitre to yield ℥ ij per Pound — it is lixiviated and chrystallized the Nitre thus produced abounds with common Salt from which it must be separated —

The German Princes are so sensible of the advantages which their country derives from the manufacture of Nitre, that they order the Peasants to build their fences of Dung & Earth, they rot in a few Years and by the treatment just described yield large quantities of Nitre —

An Old Woman & her Husband supply

the whole Electorate of Hanover with Nitre and also all which is used for Gunpowder in the Emperors Army from the scrapings of a little Town in the Electorate ——

In France it is procured from the dung and filth of Pidgeon houses, Garden mould is mixed with lime & moistened with Water — This Nitre is very impure containing much common Salt to seperate which — We know that evaporation is sufficient for the chrystallization of common Salt, we also know that Nitre will not chrystallize in boiling Water, therefore the impure Nitre is dissolved in the smallest possible quantity of boiling water, this Water is evaporated and the common Salt falls to the bottom of the Kettle as the evaporation proceeds, & must be taken out as fast as it is perceived, when much of it is seperated and the

Nitre begins also to fall, the solution is cooled and the Nitre chrystallizes and is separated – the Water is again evaporated and the same proceeding observed – This process depends on the fact that cold water dissolves as much as hot of common Salt but not near so much of Nitre – The Nitre thus obtained is tolerably pure, but not sufficiently so for the manufacture of Gun Powder, if wanted for this purpose it must be repeatedly chrystallized –

We observed that Nitre is the product of putrefaction, the Nitrous Acid is formed in this process and then Ley i.e. a solution of Potash is added and Nitre is the result – some Chemists deny this and say that putrefaction is by no means necessary to the formation of Nitre – Near Madrid in Spain it is produced by a dry Calcarous

soil & the heat of the Sun, they also say that incrustations of Nitre are often found upon Rocks and hence it derives its name of salt petre from Πετρον, Lapis, a Stone

Nitre exists in the Pump Water of our City, as well as London and other populous Cities, this happens by the Rain filtering through our Grave Yards & dissolving the Nitre which is formed & exists there it deposits it in the wells of our Pumps—

In Spain Nitre is produced from the scrapings of Cities. The Commons about Madrid are covered with immense heaps of dirt & filth — Gypsum is added to these heaps they are moistened and stirred frequently, lixiviated and chrystallized — they have now collected such immense quantities of the filth that they will probably last as long as the World for this purpose

× The best mode of making it is to add the Carbonate of Ammonia of the shops to Nitric Acid diluted with water, the Nitric acid will unite with ammonia and by evaporation will chrystalize.-

and will never fail yielding large quantities of Nitre. 4000 Men are employed in this place — It is said that Nitre is found at the bottom of some Caves in Kentucky but this has not yet been ascertained — The above facts if true of the formation of Nitre without putrefaction, seem to offer violence to established maxims in Chemistry

Nitrate of Ammoniac called also Nitrous ammonia &c — is composed of Nitric Acid & Ammonia, it possesses a cool bitter taste somewhat Nitrous, crystallizes readily — deliquesces in the Air — It evaporates by a gentle heat — if the heat be urged it detonates — The Sulphuric Acid & both the fix'd Alkalis decompose it — Its action on the inflammables is now remarkable Its action on the Metals is similar to that of the Sulphate of Ammoniac (which see)*

The Muriatic Acid – Its base is not yet absolutely known – Dr. Girtanner from many experiments upon this subject concludes it is Hydrogene gas, this opinion is refuted by Mr. Van Mons —

Dr. Girtanners experiments have been revived by Mr. Hollian, this Gentleman has obtained oxigenated muriate of Iron by exposing Iron filings to water impregnated with sulphurated hydrogene gas obtained by adding sulphuric acid diluted to a mixture of Sulphur and Iron filings, hence he concludes the base of Marine Acid is sulphurated hydrogene gas, this is now generally adopted

Marine Acid when pure & concentrated is Colourless – but that which is met with in the Shops is very yellow – pungent penetrating vapours escape from Marine Acid which resembles saffron in smell —

This Acid like every other chemical product abounds with names - Spirit of Salt Marine Acid - Acid of Sea Salt &c - in the new nomenclature Muratic Acid is appropriated to it — It turns blue vegetables red and is characterized by the usual properties of acids it acts on all the Metals but Gold —

It has no action on Animal Wax (except to whiten) and hence Anatomists use it to corrode preparations injected with wax, it corrodes and destroys the Flesh, while the wax remains unimpaired in the shape of the vessels distended with it ——

Marine Acid is never found in a disengaged state but must be procured from its combinations, Common Salt, and Sal Ammoniac are most commonly used for this purpose —— Glauber describes the process very accurately by which it is obtained &

strongly recommends the following, to take common Salt deprived by heat of all its water of crystallization, otherwise called decrepitation - this must be mixed with 8 or 9 times its weight of Clay, he kneads this water into small round balls which are dried & distilled with an intense heat, a very good and concentrated Muriatic is the Result in the Receiver and is then absorbed by Water - This process of the Old Chemists is now entirely laid aside and a much better one adopted, this is to distill a mixture of Sea Salt (decrepitated) and Sulphuric Acid in Woulfes apparatus - the Acid must be diluted before it is put into the apparatus in order to avoid inconvenience from the heat excited &c - Water is placed in the bottles to absorb the Vapour as it is disengaged, the Acid is only a solution of gas in Water - Marine acid is capable

× An easy method of obtaining Oxigenated Muriatic Acid is by throwing a few grains of Oxigenated Muriate of Potash in Muriatic Acid it instantly converts it into Oxigenated Muriatic Acid

Or by adding red Lead to Muriatic Acid or 1 part of Salt to 4 of Nitric Acid

of combining with an additional dose of oxigene and constitutes Oxigenated Muriatic Acid, we are indebted to Scheele for the discovery of this Acid, he first observed it in some experiments which had for their object the solution of the black oxide of Manganese in Marine Acid. It is procured by distilling 6 parts of Manganese, 16 of common Salt, 12 of Sulphuric Acid previously diluted with 8 of Water – Or by distilling 3 parts of Marine Acid and 1 of Manganese – In the first mode the Sulphuric Acid seizes the Soda of the common Salt forming Glaubers Salt, while the marine Acid is set at liberty, this Marine Acid seizes the Oxigene of the Manganese and becomes converted into the Oxigenated Muriatic Acid ×

## Lecture 25th

Scheele after he had discovered this

Acid, also observed its action of destroying Vegetable Colours &c — This Acid when in the form of gas is heavier than the Atmospheric Air, extinguishes a taper and is fatal to Animals respiring it — A French Chemist by the name of Pelletier respired some of this Air the consequence was an inflammation of his Lungs which terminated his existence

Water absorbs twice as much of this, as it does of Carbonic Acid gas —

Oxigenated Muriatic Acid whitens Cotton Linnens &c — and all vegetable colours with which it comes in contact, it answers very well in bleaching cotton, but the finer fibrils of Linnen are destroyed by its action before the coarse ones are perfectly white —

No vegetable colours resist entirely its action Yellow stands it longest but at last is destroyed, Soap gives a yellow colour to linens bleached with it, probably because the

Alkali of the Soap neutralizes the acid — In the process of bleaching the acid is reduced to the state of common Muriatic acid by losing its oxigene

It parts readily with its oxigene to Metals and other substances ——

If the gaseous acid be obtained and one of the following Metals in powder be thrown into it they are ignited — the oxigene gas is decomposed, its oxigene unites to the Metal and oxides it while its heat & light are disengaged, The Metallic substances which inflame most readily are 1st Regulus of Antimony 2d Chemes Mineral — 3d Cinnabar or Vermillion 4th Bismuth — 5th Zinc — 6th Iron — 7th Tin — 8th Gold and very probably some others — the first — Regulus of Antimony always produces the decomposition the others are not invariable in their effects ——

Oxigenated muriatic gas appears in form of a dense vapour in the Atmosphere —

this is probably owing to aqueous vapour which constantly floats about in the Atmosphere - for Professor Chaptal has observed that this is not perceptible on high Mountains the Specific gravity of the Water drawing it near the center of the Earth - Mr. D. Asset also makes the same observation —

This Acid bleaches the skin & Rete mucosum of a Negro as well as the Wool Doctor Beddoes first announced this experiment - the gaseous is the most proper state of the Acid to produce this effect - So you see Gentlemen Chemists have discovered a method of washing the Blackamoor White - Doc. Beddoes says he thinks the black colour of the Negroes is owing to a deficiency of oxigene - Scudiamer says rather from an abundance because he observed a patient grow black

who used a quantity of Nitrate of Mercury but upon leaving of the use of it his white colour returned ——

Beddoes persuaded a Negro man to place his Arm in a vessel containing Oxigenated Muriatic gas and at the bottom a small quantity of the liquid acid. his index & middle finger were in contact with the liquid acid after remaining in this situation a considerable time, he complained of prickling sensations about his Arm & of great uneasiness and pain in his fingers, upon one of which he had broken the skin. his whole arm & hand, more especially his two fingers which were in contact with the liquid acid, had acquired a yellow colour, his hand healed after a little inflammation, and the black colour accompanied it, may not also the peculiar factor of the Negroes be owing to a deficiency of oxigen ——

Oxigenated Muriatic Gas has been used in the Hospital at Woolwich to destroy contagion and I believe might with great advantage in many of our Hospitals ——

M. Berthollet has discovered a method of saturating the vegetable Alkali with oxigenated Muriatic acid, this combination is the oxigenated muriate of Potash — His method is to place a solution of caustic alkali in the first bottle of Woulfes apparatus and distill the oxigenated muriatic acid as usual. This liquor must be exposed to the air for the space of two or three Months when chrystals of it are obtained, (the liquor is coloured of a beautiful red), after the exposure to the air is sufficiently protracted three Salts are formed viz. Muriate of Potash — oxigenated muriate and Higher oxigenated muriate they are separated by the form of their

× It may also be inflamed by rubbing a little of this Salt upon it and dipping it in Sulphuric Acid

chrystals — the Higher oxigenated muriate chrystallizes in quadrangular plates & the oxigenated in leaves, 2 ℔ of Marine and afford not more than a few grains of the Higher oxigenated muriate which detonates with Sulphur —

It was thought this would be of great use in the manufacture of Gunpowder experiments where made on a large scale with it but the moment it was triturated with the Sulphur an explosion happened which destroyed several persons, equal parts of it and sulphur triturated in a mortar explode in a violent manner, it is dangerous to use more than half a grain in this experiment, a small quantity of this salt put upon a peice of cotton and struck upon an Anvil with a hammer inflames the cotton — a little Indigo affirts this experiment Phosphorus placed in Nitric acid inflames but this effect takes place in a much shorter time in Oxigen. Muri. acid —

Lecture 26th –

Chaptal asserts that Light disengages the surplus of oxigene from oxigenated muriatic acid – this is denied by Mr. Hoyle of Manchester, who exposed it to the action of this agent for a long time without perceiving any alteration (in Manchester Memoirs Vol. 5)

Marine acid gas when in contact with alkaline gas forms a white cloud, the oxigenated muriatic has not this effect, Cold is generated in this experiment and sal ammoniac is formed —— If oxigenated muriatic gas and alkaline gas be added together Water is produced, the oxigene of the acid unites to the Hydrogene of the Alkali and forms Water of course the oxigenated is converted to the state of ordinary muriatic acid by the loss of its pure air ——

Mr. Oken has taken notice of a curious fact which is that if the finger be dipped

into Linnid oil and then placed in oxigenated muriatic acid gas a sense of heat distinctly perceived —— Muriate of Potash or digestive Salt of Silvius is compound of the Marine acid and fixed Vegetable Alkali ——

The effects of heat and mixture are so nearly similar to that of Muriate of Soda that we will defer treating of it till we come to that substance, its chrystals are more Yellow than those of oxigenated muriate —

It is never found in a native state it is exist in some mineral waters and Vegetables from which it is to be seperated by Chemical processes — for Chemical purposes it is formed by a direct combination of its component parts, or by dbl. elective attractions

Muriate of Soda or common salt or Sea Salt &c — is compound of Marine acid and fixed fossil Alkali — Its chrystals according to De Lile are octahedral & 5 sided prisms

It detonates with ignited Charcoal and is decomposed — Many methods have been tried to disengage the fossil Alkali from this combination at a cheap rate but as yet all attempts at this have failed, one method of procuring it is to add to a solution of it, a solution of mild potash - here a double elective attraction ensues, the marine acid of the common Salt unites to the potash and forms digestive Salts of Sylvius, while the carbonic acid of the potash unites to the Soda & forms carbonate of Soda or mild fossil Alkali -

Margraaf tried Iron, Coal, Serpentine & many other substances in vain to separate the fossil Alkali cheap from this combination —

Mr Turner in England has endeavoured to procure it in his manufactory of patent Yellow his mode is to heat it intensely in contact with lead - the Marine acid of the Salt unites to the

Lead and forms Muriate of Lead or patent yellow while the fossil Alkali remains pure Barytes has been used, the Marine acid and barytes unite and leave the soda but this is expensive — The vegetable acid have been used with but little success, Sugar of Lead decomposes it, if to a solution of sugar of lead you add a solution of common Salt, a double elective attraction ensues, the Marine acid of the common Salt unites to the Lead of the sugar of Lead and forms muriate of Lead, while the soda and acetic acid unite, this last acid is separated by heat and the fossil alkali is left pure — Nitric & Sulphuric acid decompose the muriate of Soda, but this can only be used to procure the Marine acid of the Salt, for Nitrate & Sulphate of Soda are as difficultly decomposable as muriate, a cheap method remains yet to be discovered —

Some assert that Epsom Salt which is compond of Sulphuric acid & Magnesia

exist in the Water of the Sea, this is a mistake for an elective attraction would decompose it, the marine acid of the Seasalt would unite to the magnesia and the Sulphuric Acid of the Epsom Salts to the Soda & forms Muriate of Magnesia & Sulphate of Soda ——

When Alcohol is added to common Salt in a large shallow vessel and set on fire the Face of a person viewed through the blue flame has the appearance of a Corpse in a State of putrefaction ——

## Lecture 27th ——

Let us next attend to the natural history and origin of common salt and here we may say with little variation what the Poet says of Jupiter Omnia plena sunt salis —

The first sort of common salt we shall take notice of is Rock Salt, called upon account of its hardness & transparent beauty

Sal Gem — This is found in very large masses in the Salt mines at Cracow in Russia, the Mines are subterranous — Thousands live their lives out working in these Mines who never see the Sun — By reasonable calculations it appears that there is salt sufficient here to last the World a thousand Years — Four thousand Men, Women and children live and work in these Mines the only lights used here are artificial — nothing can be more horrible than the profound darkness which reigns there, some of the workman have by accident put out their lights & perished before they could be relieved or discovered ——

There exists a Mountain of rock salt at Cardova in Catalonia a province in Spain which is of a pyramidal form, three miles in circumference at its base ——

Mines of it exist in Russia, Astracan Tunis and different parts of Asia & Africa,

Also in the East Indies &c - vast quantities of it are found at Ormus, it exists in certain springs and plants the Osimum Salicum - is of this nature the peasants collect very pure salt from it, one plant often yields half an ounce per day ——

The Salt used in most of the Western countries of Europe & America is procured by evaporation from the Sea Water — A curious question has been asked here - Was the Water of the Sea originally Salt, or has it become so by washing away and dissolving Salt beds in the bowels of the Earth, to me the first opinion appears most probable that it was originally Salt or else all the springs in the Earth would be of the same Nature —

We said it is most usually procured by evaporation from sea water - the Water of the Sea differs in the quantity of salt it contains in different Latitudes - W. Boyle

says the Sea Water of the Baltic affords but half an ounce of Salt in the pound — whereas that directly under the Equator yields two ounces, this variation is owing to the evaporation of the Water by the Sun rays more under the Equator than elsewhere, and 2nd. To the immense Rains & Snows which fall in the Northern & Southern Oceans — The first cause evaporation concentrates the solution and the rains and snows tend as directly to dilute it — the reason why the difference is not much greater is that the winds and the Tides mix them together the specific gravity of Sea water to fresh is as 73 to 70 tho' this does not appear to make much odds, yet Ships and Animals swim much more readily in salt than in fresh Water — It is seperated from the Water by three different Methods, Congelation

by Heat and a Current of Air —

1st Congelation This method is used in Germany the Sea-Water is frozen, the Salt does not freeze with it but is separated and falls to the bottom of the Vessel —

2d - Evaporation by Heat - This method is most generally used, in this manner vast quantities of the Salt are prepared in France Holland, Hungary, and the Cape De Verd Islands, in some places the Seawater is placed in large evaporating vessels and fuel is applied underneath, but in most places the Suns heat is used - The Water is suffered to flow into Dams or Yards, constructed for the purpose - the heat of the Sun concentrates it very much, and the evaporation is finished by means of fuel - this mode is used in France, Genoa and Italy - In the Cape De Verd Islands the concentrated brine is suffered to remain till it chrystallizes - It is then heaped up into pyramids (while wet)

and covered over with moss, grass, weeds, &c — which are set on fire and burned, in this manner the Salt on the outside of the Pyramid is blackened and cleared off, while that in the inside is dried and is clean ——

In England and Scotland they evaporate it by means of fuel, when it is nearly ready to chrystallize it is boiled briskly, and whites of Eggs or what is more common Bullocks blood is thrown in, this coagulates by the heat and entangles all the impurities of the Salt rising with them to the top where it is skimmed off — the Salt is now supposed to chrystallize and is put into conical baskets — known by the Name of boiled Salt, the addition of the blood is called clarification —

3d Evaporation by a current of air — Is performed by pumping up the Salt water to a great height and letting it fall on a number of Bushes & Twigs, then by dividing

it expose an immense surface and innumerable particles to the air, the evaporation is of course speedy and the Salt deposits itself on the Twigs and Bushes ——

Knowing that water only is evaporated in those processes Dr. Lind has invented a mode of obtaining fresh water from Salt, it consists of evaporation in a pot covered with a top, the water rises and is condensed on the top of the pot it is nothing more than distillation, a pot of 13 Inches in diameter with a good top yields in an hour one quarter of a pound of Water perfectly pure - Lord Bacon next endeavoured to improve on this plan of procuring fresh water from Salt - Glauber in the 17th Century and also Hayle, Haplin, and others gave their assistance, but Hawkins in the 18th improved much on the original plan - In 1768 the Dolphin Frigate performed a voyage to the South Sea and procured 68 Gallons of Water in 8 Hours - In 1771 Dr. Irvine obtained 5000 £. sterling

from the British Parliament for his improvements — Mr. Musgrave procured 48 Gallons of pure Water per day by distilling the Sea Water

Sea Salt differs from every other Salt by being equally soluble in cold or hot Water ——

This salt could not (in despight of Mr. Freemans method) be manufactured to advantage in the United States during the Revolution it was made here but salt then sold at eight dollars per Bushel ——

Common salt almost always contains Magnesia this may be proven by adding to a solution of soda procured from common salt, a solution of Potash Magnesia will be precipitated, the Magnesia exists in form of Bittern i.e. Muriate of Magnesia, this only happens when the Solutions are warm ——

This Salt has been used in Medicine — Cullen used it in small doses in the Scrophula, Pringle, Mac Bride, and others have used it

with success in similar cases - It has lately been used with good effect in Hæmoptesis -

Muriate of Ammoniac or Sal Ammoniac called Sal ammoniac because it was first procured in Africa at a place where a Statue and Temple were erected in honour of Jupiter Ammon, hence also the volatile Alkali derives its name of Ammoniac, its origin is very ancient, Pliny takes notice of it, the manufacture of it was confined a long time to Africa - It is procured there by burning the Dung of Animals which feed on certain saline Plants (this is almost the only fuel used in Egypt) -

This Salt as its name indicates is compound of the Marine Acid and the volatile Alkali, both fixed alkalis and the Sulphuric acid decompose it - Quicklime assisted by heat decomposes it - heat volatilizes

it without decomposition — It is decomposed by many Metals, distilled with Iron it forms Flores Martiales with Copper Cos Veneris — It is never found in a Native state but is always an artificial production — Sal ammoniac is used in many Plasters Ointments &c — in our Dispensatories — such as the Emplastrum Ammoniac, Vogels Emplastrum volatile ammoniac &c &c — this last loses all its virtues by age and should be made when it is wanted to be used — Its principal use is in cold Tumours, Gelatinous swellings of the Olecranon, Scrophulous Ulcers & the like —

## Lecture 28th —

Borax is composed of a peculiar acid, called Acid of Borax & Soda the mineral Alkali It fuses by heat and is converted into a glassy substance, it assists greatly the fusion of the Earths Glass &c — and is therefore used

as a flux by the Glass blowers &c — It is however too costly for this purpose and is only used in very nice sorts of Glass, known by the name of Pastes which are nearly as handsome as native chrystalline Gems —

Borax is always a natural production according to Weight it is utterly impossible to form it — it is imported from the East Indies, the Merchants there get it from China Thibet &c — the Natives call it Tincall, and prepare it by lixiviating Earth in particular places which contains it — a greenish coloured Water which descends from some Mountains near those places is used in the Lixiviation — Mr. Baume says that Borax is formed in Soap Suds but this is not the case, for Carbonate of Soda is the Salt formed by the alkali of the Soap attracting the fixed Air of the Atmosphere —

Borax precipitates Metals from their solutions, probably by virtue of the alkali it contains

To these have been added Yttria
Glucine and Augustine. —

We pass next to consider the Earths, these are hard heavy infusible inodorous little Bodies totally or nearly insoluble in Water stones are characterized by these properties and consequently come under this head — The various earths beneath our Feet are all combinations of Seven primitive elementary Earths - these earthy elements are — Magnesia - Silex - Lime - Barytes - Strontites - ~~[illegible]~~ & Alumine or Pure Clay - another earth was said to have discovered by Clapworth this was called Adamantine Spar. this is proven by later discoveries to consist of several Earths - Mr. Wedgewood is also said to have discovered a new earth, in the Analysis of a Mineral from Botany Bay whether this is or is not the case is not yet determined. some Chemists have undertaken to say that all the Metals are earths

Magnesia is a white friable spongy earth

and in Medicine as an Abrorbent – Hoffman and much of it in Malignant Fevers and Acidities of the Stomach —

It was formerly prouced only from the Mother water of Nitre i.e. the Water which remains after the chrystallization of Nitre It is now obtained by adding Sulphuric or Nitric Acid to a solution of Soda prouced from common Salt, the Acid unites to the Soda & forms a Sulphate or Nitrate of Soda while the Magnesia is precipitated in form of a White Powder —

A combination of Magnesia and Marine Acid called Bittern or Muriate of Magnesia is prouced in England from Epsom Salt i.e. Sulphate of Magnesia, called Epsom Salt from a Spring at Epsom which yields it – Bittern is called also Sal Catharticus Amarus from its taste – The method of

forming it from Epsom Salt consists in adding mild Alkali to a solution of Epsom Salt, a double elective attraction ensues, the sulphuric acid of the Epsom Salt, unites to the Vegetable Alkali, while the fixed air of the Alkali unites to the Magnesia — a solution of Muriate of Potash or common Salt must be added to this and another dble. elective attraction ensues, the Marine acid of the Salt unites to the Magnesia & forms Bittern while the fixed air of the Magnesia unites to the Soda and forms mild Fossil Alkali — some use Nitre and drive off the Acid by heat but pure Potash answers best ——

Magnesia contains fixed air which must be driven off by heat, it is then called calcined Magnesia its virtues are much improved by this process ——

Magnesia is commonly called Alba to distinguish it from Manganese which

which is commonly called Magnesia Nigra
Doctor Pennington formerly a respectable
Physician in this City and a very ingenious
Chemist has proposed a Method of obtain-
ing Glaubers Salts and Bitters by a dou-
ble elective attraction - his method is to
add a solution of Muriate of Soda to
a solution of Sulphate of Magnesia -
Muriate of Magnesia & Sulphate of Soda
are produced - Magnesia exists in the
Lapis Ollaris or Potstone called potstone
because Kitchen Utensils are made of it
called soap stone from its greasy feel -
It exists also in the Arbestos or Mountain
Cork, called also Salamander Stone because
it resist the action of Fire - Cotton stone &c -
this consists of threads or filaments, The
Sarthians use it for cloathing & the Icelanders for fuel

Silex - called also flinty earth &c - Gun flints, Quartz & Sand are comprehended under this Genus of Earth, Rock chrystal contains the purest Silex we are acquainted with - Rock chrystal is found in regular chrystals which are perfectly transparent but by an intense heat acquires a milky white colour -

Silex by itself is nearly infusible, the alkaline & Neutral salts assist its fusion very greatly and form Glass if fused with them -

Nitre is used sometimes in making Glass if its oxigene assists the heat in fusing it - Borax is also used in Glass but only in that species of glass called Paste - Common sand is the most plentiful and cheapest kind of Silex and of course is used, some difficulty arises from the proportion of the Ingredients, if there be too much Alkali Acids & Water act on the Glass - if on the other hand the Silex abounds the Glass is brittle -

Our Wine decanters & Glasses are made of sand the ingredients are fused and the melted glass is taken out by the Workmen on Iron tubes and blown into the requisite form — Glass may be coloured blue by cobalt, Green by certain preparations of copper, Brown by a calx of Iron mixed with cobalt, a reddish brown by Ochres, but a handsome red can only be given it by a calx of Gold (the aurum fulminans is prepared for this use the manner in which they prepare it takes away all danger of an explosion) and Violet by Manganese

As Silex is used in the Manufacture of Porcelain or China Ware this is the most proper place to take notice of that substance It was confined for a long time to the place where it was invented Japan, from thence it travelled to China, where it was a long time kept secret but by the persevering

Industry of the Jesuits some of the earth of which it was made, was carried into France - there are two earths used one called Kaolin and the other Petunze - Mr. Reaumur was the first who experimented on this Earth he succeeded at last in analyzing it and found that the Kaolin consisted of pure clay and the Petunze of Silicious Earth - the Chinese however as much from ignorance as anything else add many foreign substances to the earths which are not of the least use - the Kaolin is prepared by washing pure clay drying it and powdering it very fine, the Petunze is also washed, very finely powdered and mixed with the Kaolin, they are made into a paste with water - This is formed while in the state of Paste into Cups or any desired figure and baked with a smart heat, this is called the biscuit, the next process is to

put on the Enamel this also was long a secret, but it is now well known that it is nothing more than a coat of Glass on the Biscuit, to apply this coat white glass is powdered very finely and mixed with water to a proper consistence, the Biscuit is dipped into this paste and becomes covered with it when it dries various designs are painted on it with vitrifiable colours, as the oxides of Metals, the vessels are now heated intensely the Glass & colours fuse and give them a very polished and elegant coat of enamel, the vessels are now set by for use & exportation —

Some difficulty occurs in the proportion of the Kaolin and Petunze, frequent experiments alone can determine this point —

We said that Rock Chrystal is the purest Silicious earth that is found natively, it contains 93 parts in 100 pure Silex Feld Spar is next in purity to this —

Silex exists in the Terra Sigillata so called because they are marked with the Seal of the Grand Seignior - they appear to consist of Schol and Silex — Silex is not soluble in any Acid but the Fluoric of which more hereafter —

Silex has been found combined with a number of foreign Matters in a supposed artificial Wall but which is really a natural production in North Carolina viz Basaltes for a particular account of this Super to the Medical repository of N. York

## Lecture 29th —

Lime or Calcareous earth is next in order this forms the basis of Marble which consists of Lime and Carbonic Acid, there are three kinds of Marble - 1st the White this is the purest we are acquainted with much of the White marble was formerly found in the Island of Paros, famed on

accounts of the statues made there which exceed in Beauty (as to whiteness) any in the World, this consists entirely of Lime & fixed air

2d The variegated or spotted is coloured by foreign matters and of course not so pure - this variety represents a thousand different things, some is figured with representations of Animals and Vegetables, some is merely coloured in irregular splotches - the white Marble may be stained artificially so as to represent the variegated -

3d The Coloured, this is of one uniform colour Red, Blue, Green, Black &c - this is the only circumstance in which it differs from the others, it is usually coloured by a Metallic oxide, under this head we may comprehend the Stalactites or Petrifactions

Buffaloes dung has been found petrified near the River Ohio in the back part of the United States - the place where

* Sulphate of Ammonia may be prouid by adding a solution of pure Ammonia to Gypsum no action takes place untill the Mixture has stood 8 or 10 days, the Ammonia is converted into carbonate of Ammonia by abroobing carbonic Acid from the Atmosphere, a dbl. elective attraction takes place the carbonic Acid of the carbonate of Ammonia unites to the lime of the Sulphate of Lime and forms Carbonate of Lime while the Sulphuric Acid of the Sulphate of

those petrifactions are found is in a Spring near the Ohio, Bunches of Grapes have also been found petrified by dropping into the Calcareous Springs – this Phenomenon is by no means to be ascribed to an actual conversion of the Grapes &c – into stone, but to a deposition of Calcareous particles into the cavities of the Grapes or Dung &c – –

* Lime united with Sulphuric Acid forms Gypsum, Plaster of Paris &c – with Nitric Acid Nitrate – and Marine Muriate of Lime this Muriate of Lime (in a Crystallized form) fused with snow produces a most intense degree of cold – Mercury may be frozen in this Manner, a congealed Mass weighing 56 ℔ has been made – (see Mercury) A quantity of the Mixture rubbed between the fingers, gives nearly the same sensation as a hot coal – Lime is soluble in highly concentrated

Muriate of Lime may be obtained by saturating the muriatic acid with slacked lime, evaporate to the consistence of honey, then set it by to chrystalize, these chrystals must be kept in a close stopped vial or they will become fluid by attracting moisture from the atmosphere. -

Acetic Acid; The mild Alkalies added to Quicklime lose their fixed Air and become caustic, owing to the superior attraction which the Lime has to it, overcoming that of the Alkali — To this fixed air Lime has so strong an affinity that fire alone will separate it, by means of this agent Lime stone which consists of pure Lime and fixed air and also Marble are converted into Lime fit for building, a species of Marble has been found in Lancaster (which is very good for Statuaries but) which is commonly used to burn and be converted into Lime — A sort of inverted conical Furnace is made use of for the combustion of Lime stone (the form of which is nearly that of the inside of a Crucible) the lime stone is placed in the furnace and a fire kindled; the heat is raised & kept

up till all the fixed air is driven off hence People who unwarily lie down near a lime kiln are often killed by respiring the fixed air disengaged in this process, the lime thus prepared is tolerably pure

Water added to Lime causes it to crumble into powder with the emission of much heat, indeed if this operation which is called Slaking is performed in a dark Room light is disengaged so great is the heat — this heat is disengaged by the Water in passing from a fluid to a solid state, if more Water be added the Lime forms a kind of paste which with the addition of sand forms Mortar — Some have supposed that from the hardness of the mortar of the Ancients they were possessed of a secret made of making it, with which we are unacquainted ~~without~~ those admirers

of Antiquity are certainly wrong the only reason of the superior hardness of their Mortar is. the greater length of time it has stood, the longer it is exposed to the Atmosphere the harder mortar grows by absorbing more Carbonic Acid from it –

We said great heat is produced in the slacking of Lime this is sufficient to fuse Sulphur and in this manner Hepar of Lime is usually made – Lime is partially soluble in Water perhaps about 480 times its own weight this Solution forms the Aqua Calcis or Lime Water – Lime Water possesses one property of the Alkalis viz. that of turning blue vegetables Green – If exposed to the air a scum forms on its surface, of regenerated Lime stone or Carbonate of Lime, owing to its attracting fixed air from the Atmosphere this is called Cream of Lime, another mode

Phosphuret of Lime may be obtained by placing a peice of phosphorus at the bottom of a glass tube, and putting lime over, the lime must be exposed to an intense heat and the phosphorus sublimed through it. This Phosphuret of lime decomposes water, the oxygene of the water unites to the phosphorus and forms phosphoric acid, this unites to the lime and forms a phosphate of lime, the hydrogen of the water dissolves a portion of the phosphorus and escapes in the form of phosphurated hydrogene gas. —

of decomposing Lime water is by evaporation
Lime water is useful in scalds, burns, &c —
Olive Oil is often agitated with for this purpose — Lime forms the basis of our bones it exist in them in form of a Phosphate —
Lime is often used as a Manure, but the sulphate of Lime or Gypsum answers much better for this purpose, this we shall treat of in our next Lecture, we pass on now & consider

Barytes or Ponderous Earth, this earth is never found pure the following 3 states are the most common in which it is obtained 1st In combination with carbonic Acid — this Carbonate is soluble in Muriatic acid if the Acid be heated Muriated Barytes is formed says Mr Poke of Edinburgh Doctor Priestly denies this — 2d Muriated Barytes is the most common this combination from its great specific gravity is called Marmor Metallicum — 3d Lapis Hepaticus or

Liver Stone this is a compound of Sulphuric Acid and Ponderous earth, it is found in Albemarle in Virginia —

There are two Methods of obtaining the Barytes from this Liver Stone – the

1st By adding Marine Acid which displaces the Sulphuric & forms the Muriated Barytes

2d By heating it in contact with about one eight part of Charcoal the coal absorbs the pure air of the Sulphuric Acid and forms fixed air while the sulphur & Barytes are left in a pure state – If the first mode be used the Muriated Barytes is to be decomposed by carbonate of Potash. a double elective attraction ensues, the carbonic Acid of the carbonate unites to the Barytes and forms carbonate of Barytes while the Marine Acid and Potash Unite and form Digestive Salt of Silvius – the Carbonic Acid can only be separated by calcination as in Lime – and heat

is requisite in the decomposition of the Muriated Barytes — Muriated Barytes is used to detect the Presence of Sulphuric Acid in Water, it forms a white insoluble compound with the Sulphuric Acid & detects a very small quantity of the Acid — Barytes is as strong & effectual a poison as Arsenic —

Muriated Barytes has been used in cases of Scrophula Doc. Ferriar says he has used it and been much disappointed for it had very little effect, he is disposed to believe it does good only by the Acid it contains, this he infers from his own experience, for he has used the Barytes in form of Muriate with Surgical Patients who were not relieved by it, immediately on using the disengaged Acid his Patients were cured ——

Strontites or Strontian Earth is found principally in the Lead Mines of Argyleshire in Scotland the concentrated Nitric Acid

has no action on this Earth but when diluted dissolves it with rapidity —

It differs from the two last described Earths – 1st Because it forms different compounds with the Acids – 2d Because it cannot be converted into Lime by combustion —

3d Its chrystals are different – & 4th It does not form bone with Phosphoric Acid

Terra Saxonia We have little to say of this Earth, beside shewing a specimen of it – It is soluble in the Sulphuric Acid – and remarkable for its hardness as it cuts glass as readily as the Diamond ——

Alumine – Pure clay or Argillaceous Earth &c – The earth supposed to have been discovered by Clapworth & called on account of its hardness Adamantine Spar is composed of this Earth (Alumine) united to Magnesia and Iron – Doct. Seybert has discovered Adamantine Spar on Chesnut-hill near

Germantown - it possesses the property of the diamond of cutting glass — Pure clay possesses the following properties —

1st It cannot be converted into Lime by calcination —

2d - It is soluble in the Nitric, Sulphuric & Muriatic Acids - with the Sulphuric it forms Alum - this combination is commonly made use of to procure the Earth in its purest state, this effected by adding to a solution of Alum, a solution of Potash, the Sulphuric Acid and Potash unite forming vitriolated Tartar while the Alumine is precipitated in form of a white powder - 3d It forms a paste with Water.

4th - It is fusible by a very intense heat, according to Lavoisier it require a flame supported by oxigenous gas to produce this effect, what is very curious a Crucible of Chalk must be used in this experiment - Clay will not fuse in a crucible of Clay —

# Lecture 30th

We next pass to the consideration of the Earths with Acids &c —

I Gypsum or Plaster of Paris is compound of the Sulphuric Acid and Lime about equal parts of each, tho' different Specimens contain different quantities of each — If the acid be not saturated it effervesces when more of the Earth is added — Gypsum abounds in the bowels of the Earth large quantities are found in Nova Scotia, its principle use is in Agriculture being used as a Manure Gypsum is undecomposable by heat, Geoffroy exposed 100 lb. to intense heat six days & nights and produced only ℥6 of Acid — If heated strongly it crumbles into powder this powder mixed with water so as to form paste and poured into a mould yields us any impression we wish — In this manner Medals are represented by placing Tinfoil round them — pressing it close and putting it in a vessel filled with Gypsum in powder then

adding Water — Gypsum chrystallizes in rhomboidal octahedrons —

It is found in vast banks near Paris hence its name, also in York County in this State how Gypsum acts as a Manure I cannot say unless by its Stimulus ——

II Alum is compound of Sulphuric Acid and Pure Clay, all the Alkalis decompose Alum and precipitate the Earth — Heat alone has no very powerful action on it — heated in contact with Charcoal its Acid is decompond, fixed Air is formed and the Alumine is left in a pure state — about one tenth consists of Sulphuric Acid and nine tenths Earth ——

Pyrophorus a very curious product of Chemistry is procured from Alum, for this purpose 3 parts of Alum are mixed with 1 of Meal Honey, Sugar, or any carbonacous vegetable substance, it is put into a clean vial, coated well with Clay and closed with a stopper of

the same Earth, several of those vials are put into a crucible filled with Powdered Charcoal, this must be exposed to an intense heat the use of the Coal is to prevent the access of pure Air to the Pyrophorus, which would cause it to inflame, the Pyrophorus when made kindles instantly on exposure to the air, especially if the air be moist & warm as the Breath – To account for this really curious Phenomenon many Theories have been formed, some thought it was owing to a quantity of highly concentrated Sulphuric Acid which existed in the Pyrophorus – this is not the case 1st – Because no Acid can be detected in the Pyrophorus by blue vegetables and 2ndly – Because Sulphuric Acid will not inflame Charcoal – Mr. Beckly thought it was owing to Nitric Acid, because Nitric Acid added to Coal inflames it – the fact is true and Nitrous Acid assists the

inflammation of Pyrophoros, but as we said before no disengaged Acid whatever exists in Pyrophoros – This point ascertained he supposed that the Nitrous Acid existed in sufficient quantity in the Atmosphere to answer this purpose, but we have already disproved this hypothesis (as Nit. Acid) – Again it was thought that the inflammation was owing to Sulphurated Hydrogene Gas, this they say is produced by a small quantity of Water which exists in the Meal, Sugar &c – and which is decomposed, – and that the sulphuric Acid of the Alum is decomposed and affords Sulphur which is dissolved by the hydrogene gas of the Water and so forms sulphurated hydrogene Gas which takes fire on coming in contact with the pure Air of the Atmosphere – Some say the sulphur unites with Potash and forms Hepar Sulphuris which emits the Sulphurated Hydrogene Gas –

This hypothesis tho'a very ingenious one is like the others fallacious, for Sulphurated hydrogene gas never takes fire spontaneously — the only way in which I can account for it is that Phosphorated hydrogene is disengaged which we know will kindle in the common temperature of the Air — that vegetable matter contains phosphorus is very evident witness the Light Wood as it is turned &c — Besides Pyrophorus has been analyzed and ℥i of it found to contain 5 grains of Phosphorus — To return to Alum —

It is soluble in Water here we again see the astonishing changes produced in bodies by Chemical union the Sulphuric Acid under the insoluble clay perfectly soluble —

Alum is used to clear muddy Water, if a peice of Alum is thrown into muddy Water, the Water is turned as clear & limpid as Rock Water, this is explained by supposing the Acid of the Alum not saturated it consequently dissolves more clay — Wines

are sometimes clarified in this manner but milk is preferable for this purpose —

Alum is found in Pyrites, Arsenic Sulphur, Iron &c - often are found in this Pyrites, the Alum is Separated by Solution and subsequent Crystallization —

Alum is often used in making Ink Dyes &c — but it is only proper for red colours Potash is much more useful in the formation of Ink. —

Alum is used in Medicine as an Astringent which it is in a most powerful manner - the dose at first is 4 or 5 grains three or four times a day, to be afterwards increased to what the Stomach will bear It has been used in inflammations of the Lungs, Uterus &c - with success - It greatly increases the astringency of the Bark this happens by the Acid (which usually

predominates in the Alum) uniting with some Clay (with which the Gallic Acid forms the astringent principle) here Alum is formed.

III Fluor Spar, called in the New Nomenclature Fluate of Lime, also called Derbyshire Spar - Phosphoric Spar - Vitreous Spar - &c - It is composed of Lime and a very peculiar Acid known by the name of the Fluoric - this acid exists pure only in the gaseous state - It is fatal to Animal Life and combustion and possesses the property of dissolving glass and Silicious earths hence it is used to engrave on glass in the same manner as Nitric Acid is to Etch on Copper - Its smell resembles that of marine acid and indeed it was long thought to be nothing more than a very highly oxigenated Muriatic Acid —

The usual mode of procuring the Fluoric Acid is by adding Sulphuric Acid

to Fluor Spar and proceeding to distill with a gentle heat, the Beak of the Retort is inverted under the Shelf of the Hydro-pneumatic apparatus, the Acid comes over in a gaseous form and deposits Silex on the surface of the Water, this frequently comes from the Retort, but Lime from the Spar is much more common — As a low degree of heat is sufficient for this distillation Leaden Retorts may be used which are not attacked by the Fluoric Acid

Dr. Priestly says the thickest glass retorts he could procure were corroded through in a quarter of an hour —

Fluoric Acid is a very accurate test for Magnesian Earth ——

Having touched upon each of the Earths in the order set down & said a few words on their most common combinations with the acids, We proceed to the next subject in order —

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